FORECASTING FOR INTERCITY AIR CARGO DEMAND

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by

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ABSTRACT

In the study of business administration or management the student soon encounters a problem that those in the field of air cargo know only too well, the fact that decisions must be made under conditions of uncertainty. The forecasting of intercity air cargo demand is an attempt to reduce this uncertainty and allow the manager or executive make better decisions. However, in air cargo, as in any other industry, there is a wide range of forecasting techniques available. The forecaster could use consensus, trend projection, factor correlation, single and multiple regression, econometric models, or input/output tables.

Many of the existing forecasts were examined and classified as were several projected methods. They were classified as to technique employed, the scope of the forecast, or possible scope, the time horizon considered, or that could be considered, and the type of material forecast. This was done in order to generate a feel for what methods could best fit what situations. Use was the criteria established for present worth.

There are many associative and causative factors which must be understood in order to better forecast future intercity air cargo demand. These factors were discussed

in an attempt to isolate the most important. The attempt to isolate these factors was coupled with the classification of the forecasting methods to arrive at a set of conclusions and recommendations. Included in these were the lack of a proper data base and the direction to be taken in further research. It was concluded that, overall, the state of the art must wait for more reliable data before more precise techniques are valid.

PART 1

INTRODUCTION

In the study of business administration or management the student soon encounters a problem that those in the field of air cargo know only too well, the fact that decisions must be made under conditions of uncertainty. He discovers that while the future is not certain, he must make decisions based upon his best estimate of what the future will bring. He must somehow predict or forecast future events as accurately as possible. This forecasting may be correctly described as a science, an art, or both. The forecaster of future intercity air cargo demand has a wide variety of techniques at this disposal. These techniques include consensus, trend projection, factor correlation, single and multiple regression, econometric models, and input/output tables. The choice of any one, or any combination, of them is dependent upon the forecaster's objectives and specific circumstances. Such factors as how long into the future must he project, how accurate must he be, what kind of output does he need, and what kind of data does he have available, will greatly influence his selection.

There are many reasons why the forecasting of future intercity air cargo demand is necessary. This information is needed on an international, national, regional,

and local level. It is also needed by the air carriers and the equipment manufacturers. The future level of intercity air cargo demand influences decisions regarding rate structure, route structure, facility capacities, air carrier capacities, and other regulatory and standardization requirements. At the international level the bodies concerned with the regulation of international air cargo need to know future demand so that they can better prepare gateway airport facilities to handle this demand. The structuring of international routes to handle this demand is important. There are many other regulatory decisions that must be made to facilitate the international flow of air cargo and a forecast of future demand is neccessary, to ensure that the best decisions are made. At the national level there is the need for planning our national transportation system.[30] As air cargo is a portion of this system, a forecast of future demand and its relation to other parts of the system is necessary. Again we must make decisions concerning rate structure, which affects competition between modes, and route structure. The Federal Aviation Agency (FAA) needs to know future demand so that it can plan future facility expansion. Regionally, we have such studies as the Northeast Corridor Project which approaches the same decisions but on a lower aggregate level. The local airport

is concerned with future demand at its level so that it can better meet future requirements and plan any needed expansion or change more efficiently. The carriers are concerned with future levels and make-up (such as length of flight, origination, average weight, etc.) so that they can better prepare for any needed capacity changes. And finally, the equipment manufacturers are concerned with future demand and what types of equipment will be necessary. They are interested in the changes or improvements in technology that will be required to satisfy the demand.

When the financing requirements for future facilities expansion is considered, when the expected lifetimes of the new equipment are considered, and when the lead time necessary to arrive at and implement the decisions required in planning the national and international transportation system are considered it becomes readily apparent that the best possible forecasts of intercity air cargo demand must be made.

My intention is to examine the techniques that are presently available to the forecaster of intercity air cargo and determine the applicability of these various techniques to specific sets of circumstances that confront him. I will examine the factors that affect air cargo. I will also show how some forecasts are being used. And

finally, I will address myself to various problems present today and set forth some conclusions that I reached concerning the forecasting of intercity air cargo.

PART 2

CLASSIFICATION OF FORECASTS

A. Methods of Classification

Introduction

There are many forecasts of intercity air cargo demand, employing numerous forecasting techniques, presently being made that vary greatly in complexity and scope. When one first encounters this broad array it is very easy to be seduced into an attempt to compare all of these various forecasts down to their minutest detail. It is also possible to argue endlessly the relative merits of the many forecasts that have been made, although to no extremely constructive end. The competing forecasting techniques are not equally applicable to all situations and thus the forecaster must pick and choose the one that is best for him.

After the initial shock is over the forecasting methods begin to fall into various broad categories. It can be seen that while there are small differences, certain forecasts have much in common with certain other forecasts. More of a feel for intercity air cargo forecasting can be obtained by segregating the forecasts into these broad categories and examining their implications. Of the many ways that forecasts could be classified the most beneficial categories are by technique, by the scope

of the forecast, by its period of interest, and by the type of material forecast.

Classification by technique

As previously stated, the forecaster has a wide range of techniques available with varying degrees of complexity. These techniques can be grouped into three broad categories: The naive method, the barometric method, and the analytical method.[39]

The naive method. A forecasting technique would be classified as naive if it lacked a rigid theoretical basis. An example would be the mechanical extrapolation of a time series into the future. It is assumed that the future is some kind of extension of the past.[39] This method would require a minimum of data and at the same time would give the forecaster a reasonable estimate of future demand. Naturally, the further into the future that the forecast went the wider the confidence interval would be and the less satisfactory the method becomes.

The barometric method. Under the barometric method it is implied that past historical patterns tend to repeat themselves in the future. It assumes that the future can be predicted from certain happenings in the present. "Thus, past statistical behavior that seems to be associated regularly with fluctuations in particular series or general business conditions, is discovered and used as a basis for

forecasting. Foreshadowing series are searched to provide an advance reading of what is expected to follow in the series to be forecasted. The search for foreshadowing series is not based on the leads actually revealed by historical data alone. Theoretical considerations as to the leads and lags in various series are also employed. Cross-checking between empiricism and theory in the search for leading series is the best method for establishing the thesis that the future does not represent a break from the past but that changes are largely determined by present conditions. The foreshadowing or leading series selected serve as barometers of future changes in specific series or general business conditions. The barometric method, therefore, involves the use of a statistical indicator or indicators, that would provide an indication as to the direction a specific time series is heading."[39]

<u>The analytical method</u>. This method entails a detailed analysis of causative forces operating currently on the variable to be predicted. Current data is analyzed to discover cause and effect relationships and these are used to judge the future cause of the causative forces and the effect they will have on the variables to be predicted. Analytical methods may be non-mathematical, such as opinion polling; or mathematical, such as econometric models. This method requires a careful analysis of forces at work in

order to establish useful quantitative relationships. This analysis by no means excludes the use of past statistical relationships to make the forecast. In fact, historical patterns are often used to estimate the constants used in the mathematical models.[39] This method requires quite complete data to be effective.

Classification by scope

Air transport forecasts differ according to the limits within which they are confined in space. Whether the forecaster is interested in a single route or is predicting free world air cargo will greatly influence his assumptions and the number of factors that he must consider. The three general classifications are forecasts bearing on a single route or geographic point, forecasts bearing on a complete network, and forecasts of a vast geographical scale.[7]

Single route or geographic point forecasts. The forecaster could well be interested in predicting future activity along a single route or at a single geographic point. In this case the problem is quite well defined and can be studied by taking into account particular characteristics and local factors.[7] The forecaster would be very interested in predicting seasonal fluctuations as well as overall trends.

Complete network forecasts. The next level would be forecasts prepared for a complete network by an operator or for a more complex regional network. It can still be studied relatively independently of anything going on outside it. The network will be more or less homogeneous but will require a more complete analysis than the single route. A more complete range of factors must be considered and the analysis must be done either sector by sector or by establishing different customer categories.[7] The forecaster is still interested is predicting seasonal fluctuations but is now more interested in average performance.

Vast geographical forecasts. This final level would be comprised of both numerous routes (national or international) and many operators of all sizes. The problem is now so large that it is impossible to devote attention to special cases. The forecaster will be working with average values or average distances due to the applicability of the law of large numbers.[7] The interdependencies have become so complex that the forecaster cannot isolate himself from occurances outside the air cargo system.

Classification by period of interest

As stated by G. Besse, "we also find quite distinct working methods, depending on the period ahead in which we are interested or to put it another way, the 'horizon' that we are adpoting."[7] After an examination of various

ways to determine the length of the periods it would appear that the classicial approach is best. Therefore, the forecasts will be classified as short term, medium term, and long term. The different time periods place varying demands on the forecasts with respect to accuracy and kind of data required. The forecasts are also of interest to different levels of management depending upon the time horizon considered.

Short term forecasts. The short term forecasts are those which predict activity for a period up to two years into the future. These forecasts are generally useful at the operational level. That is, for example, the airport manager or airline executive who is concerned with day to day activites and must ensure that the necessary capacity is available to handle today's traffic. The forecast should, ideally, entail a high degree of accuracy. The executive is interested in all of the cyclical, seasonal, and accidental variations that may affect the demand. The data required for this forecast would have to be highly disaggregated.

Medium term forecast. A forecast concerned with the period two to five years hence would be classified as medium term. This type of forecast is a balance between the needs of the operational executive and the planning executive. There are many decisions in the air cargo,

industry which require lead times that are in this range. An example would be the National Airport Plan which is concerned with a five year horizon.[26] Some of the accuracy requirements will have been removed and some seasonal, cyclical, and accidental variations as well. The data used would still be highly disaggregated.

Long term forecast. Forecasts with a time horizon of ten years or more are long term forecasts. They are mainly of interest to the planning executive and to the research and development departments. This type of forecast would be involved with trends and would remove as much seasonal, cyclical, and accidential variations as possible. The accuracy requirements are relaxed and the confidence intervals expand as the horizon lengthens. The data may or may not be disaggregated.

Classification by type of material forecast

The many forecasts also differ by the type of material that they are concerned with. One group is concerned only with commercial data. Another forecast involves the prediction of air operations. And a third group is concerned with economic calculations.[7] These forecasts vary as to who they interest and how they are used. Data is again an important factor as its degree of aggregation or disaggregation and its completeness can severely limit what can be forecast from it.

Commerical data forecasts. Commercial data forecasts are concerned with expected revenues, tons of cargo carried, volume of traffic related to distance, and similar data. The characteristics of an operation are not of interest, only the results, the trend in demand.[7] These forecasts would be of interest to the airlines in particular and to the whole industry in general as they give a broad overview of air cargo. "The data is related essentially to factors connected with the political, economic, and demographic situation."[7]

Air operations forecasts. These forecasts are concerned with number and rate of movements, miles flown, departure frequencies, the daily or weekly distribution of demand, etc. Their aim is to facilitate an optimum adaptation of available facilities and the planning of future facilities. These forecasts are concerned with the organization of air transport and the best use of the instruments now available to it and which may be available subsequently. Both operational and planning executives are involved in this process and thus are interested in this type of output.[7]

Economic calculation forecasts. The final category is the grouping of forecasts that are involved with economic calculations. That is, they take into account such factors as preference given to speed, the effect of price, the effect of the quality and availability of service.[7] They

are also concerned with the organization of air transport and the definition and arrangement of its constituent parts.

B. Classification of Present Forecasts

Introduction

Many organizations and people have either made forecasts or have described methods that could be used. These include the forecasts of the Federal Aviation Administration (FAA), Douglas Aircraft Company, Lockheed-Georiga Company, Boeing Company, Resources for the Future, the Air Transport Association (ATA), and Arthur D. Little, Inc. There have also been papers written by Karen R. Polenske, W. B. Allen, W. W. Coterman, W. A. Jessiman, and Richard Lawson among others. These forecasts and the methods discussed in the papers can be classified according to the scheme previously presented. Each can be described by technique employed, scope, period of interest, and type of material forecast. A summary of these classifications can be found in Table III.

FAA Aviation Forecasts: Fiscal Year 1967-1977;[28] Fiscal Years 1971-1982[29]

The FAA publishes a forecast yearly which predicts aviation traffic of United States airlines for the following 10 years. The forecast is based mostly on the application of historical trends to present data. However, judgment

factors are interjected and historical trends can be amended as they were in the fiscal year 1971-1982 forecast.[29] These forecasts are designed to be used in preparing the FAA 5-year plan. However, it also has short term and long term application as well. As depicted in Table I, the forecast predicts operations data. Arrivals, departures, and instrument operations are predicted in addition to revenue aircraft miles. This is only natural as the FAA is principally interested in the movement of aircraft. Information such as this is necessary to plan control towers, runway capacity, and apron requirements.

<u>Aviation Demand and Airport Facility Requirement Forecasts for Large Air Transportation Hubs</u>[27]

The FAA also forecasts demand at 21 large air transportation hubs. The forecast covered the years 1970-1980 for the purpose of forecasting aviation demand and developing a facility forecast for 1980. Growth rates for air cargo were assumed to be 19-20% annually for domestic cargo and 25% annually for international cargo. Each airport was forecasted separately with the airports' past relationships to national and international trends and the resulting growth rates applied to present data. The material forecast was again such operational items as arrivals and departures, and cargo tons. The forecast also aggregated the hub forecasts to obtain a summary forecast.

TABLE I

TOTAL REVENUE AIRCRAFT MILES, UNITED STATES AIR CARRIERS

(In Millions)

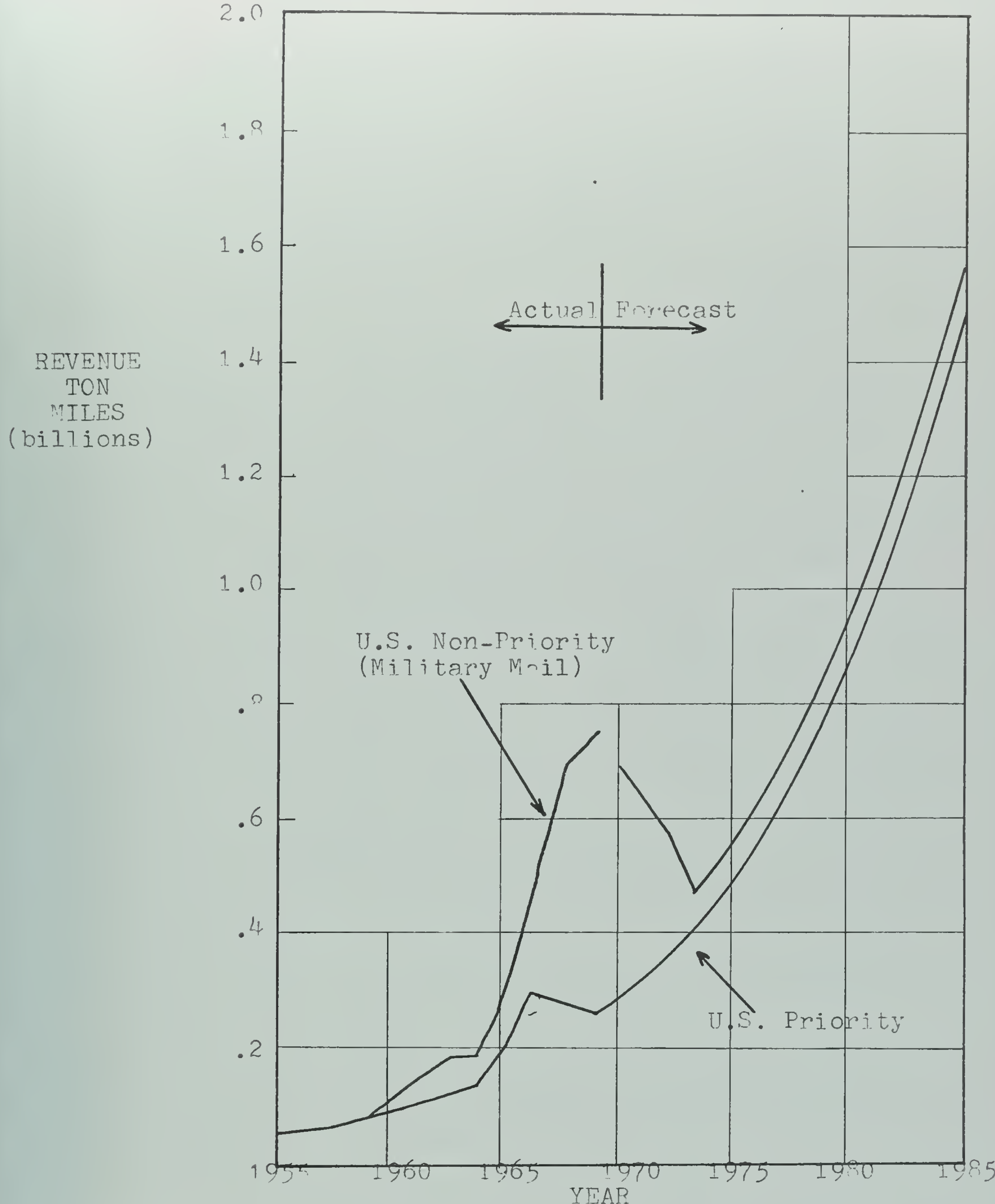
Aircraft Type	Reported FY 1966	FY 1967	FY 1968	FY 1969	Forecast FY 1970	FY 1971	FY 1972	FY 1973	FY 1977
Total Aircraft	1,615	1,857	2,096	2,244	2,427	2,599	2,758	2,934	3,613
Fixed-wing Aircraft	1,613	1,855	2,093	2,241	[illegible]	1,596	1,755	2,931	2,609
Jet	1,087	1,365	1,712	1,905	2,191	2,367	2,522	2,709	3,330
2 & 3 engine	233	444	627	[illegible]	904	681	1,057	1,137	1,444
4 engine	854	921	1,085	1,177	1,287	1,296	1,465	1,534	1,632
SST	-	-	-	-	-	-	-	39	254
Turboprop	200	231	252	193	185	184	181	181	221
1 & 2 engine	50	88	134	148	154	157	164	167	213
4 engine	150	143	118	45	31	17	17	14	8
Piston	326	259	129	63	49	45	42	31	8
1 & 2 engine	166	119	45	15	14	14	14	10	2
4 engine	160	140	84	48	34	31	18	21	6

NOTE - Included here are revenue miles flown by all passenger and cargo aircraft owned or leased by, and in the domestic or international service of the United States certificated route, supplemental, intrastate and contract air carriers. Miles for fiscal year 1966 are partially estimated.

SOURCE: Federal Aviation Administration, Aviation Forecasts Fiscal Years, 1967-1977, report by the office of Aviation Economics (January 1971), p. 24.

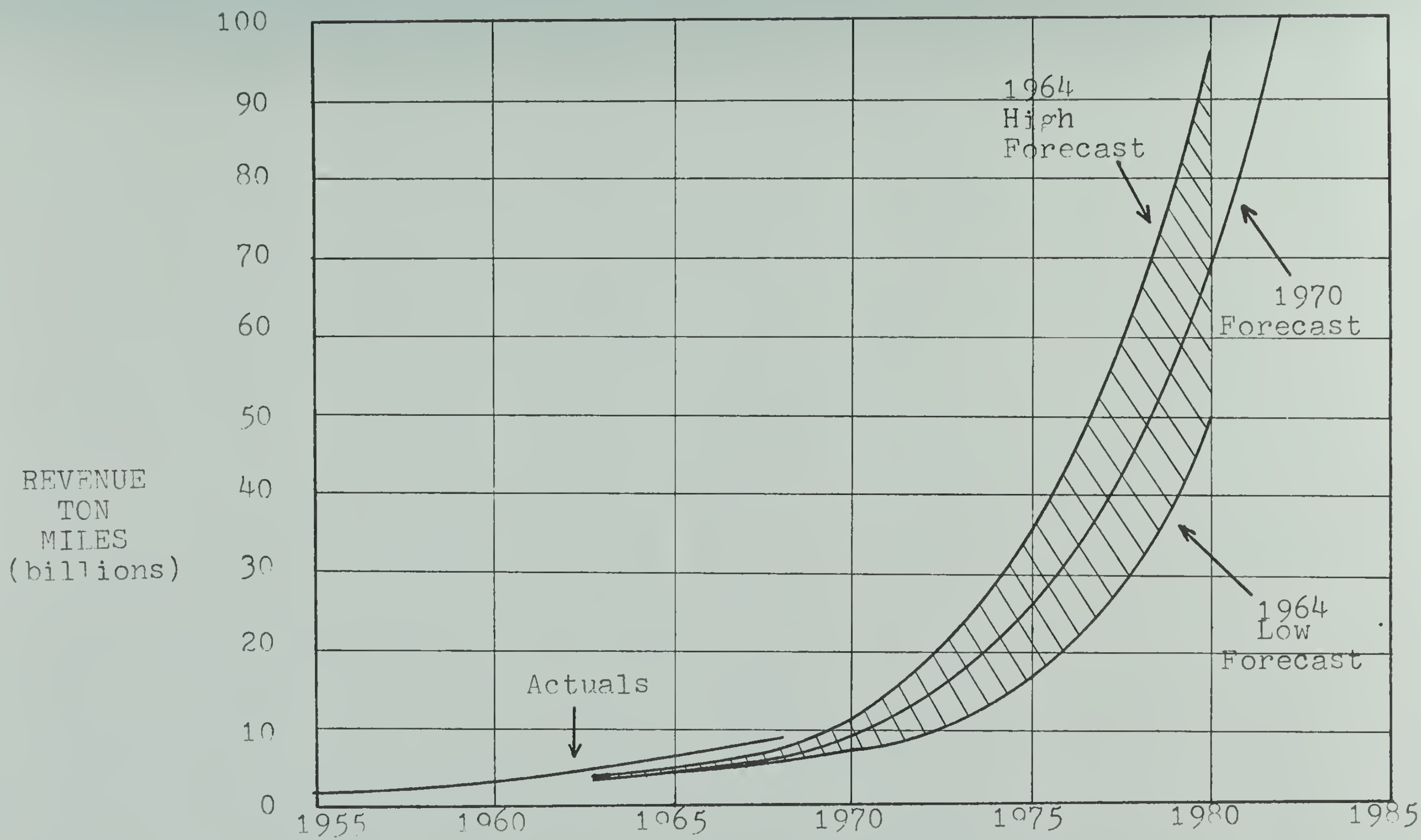
McDonnell-Douglas Corporation (MDC) air cargo forecast[18]

The MDC forecast first segregated the market into sections which were later combined into a single forecast. While the forecasts were basically trend projections, qualitative factors were also introduced. An example can be illustrated with Figure 2.1. A large portion of airlift mail traffic in 1969 was military. The MDC forecast has determined that this will decline, although the trend at that point doesn't suggest it, and adjusts the prediction accordingly. The controlling factor in this action would appear to be the predicted withdrawal from Vietnam. The forecast is concerned with the total free world air cargo and predicts the revenue ton-miles. Although there is a forecasted demand for every year from 1970 to 1985 the time horizon is principally long range. All variations have been stripped away from the trends and the forecast is primarily geared to the long term planning executive. The data generated are average values and there could well be variations both above and below. The confidence intervals of the forecast can be somewhat depicted in Figure 2.2. The high and low forecasts encompass a range of values that the actual demand could well be. The further into the future the forecast goes the wider the possible range of demand. The MDC forecast of free world traffic is contained in Figure 2.3.



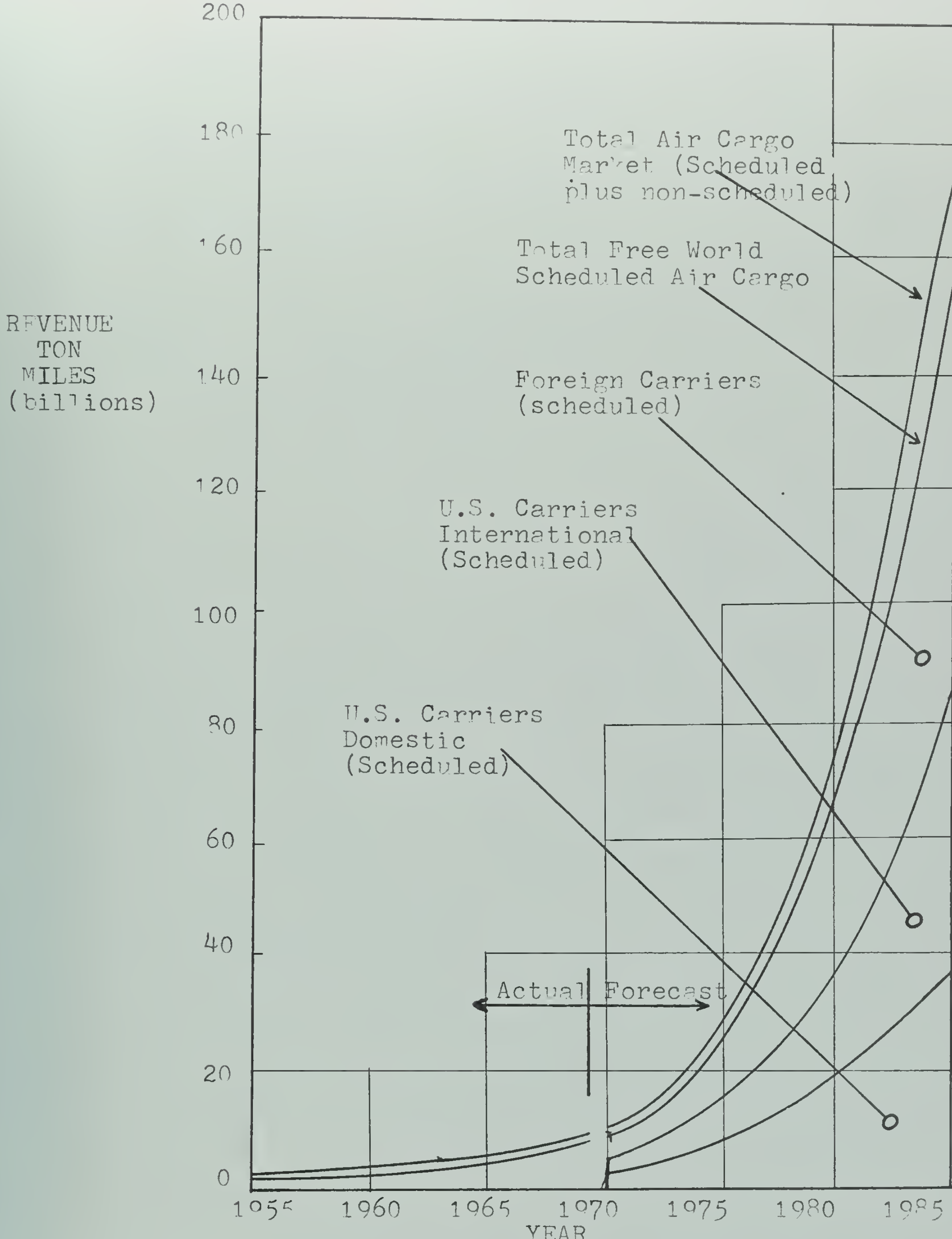
SOURCE: E. W. Eckard, Air Cargo Growth Study, Cargo Marketing Research Section no. 99 (Marietta, Georgia: Lockheed-Georgia Company (1967)), p. 28.

Figure 2.1 MDC Forecast of International Scheduled Airlift Mail Traffic for U.S. Airlines



SOURCE: Douglas Aircraft Company, _A Guide to Commercial Air Cargo Development and the McDonnell Douglas Corporation Air Cargo Forecast_, report no. C1-801-L0107 (September 1969, revised December 1970), p. 6.

Figure 2.2 Comparison of Various MDC Air Cargo Forecasts



SOURCE: Douglas Aircraft Company, A Guide to Commercial Air Cargo Development and the McDonnell Douglas Corporation Air Cargo Forecast, report no. C1-801-L0107 (September 1969, revised December 1970), p. 47.

Figure 2.3 MDC Forecast of Total Free-World Air Cargo Traffic

FORPAC[39]

In its FORPAC model, the McDonnell-Douglas Corporation makes a distinction between projection and forecast. The basic distinction is that projections employ a naive technique while forecasts are analytical. The FORPAC model presents the user with 8 options as to the technique he wishes to employ. The technique chosen is highly dependent on the past data available, the time horizon desired, and the degree of accuracy required. All of the techniques are single route in scope as the model analyzes using city-pairs. They all also predict revenue ton-miles.

Inputted forecasted growth rates. This option would be used if the historical data was unreliable. It can be used for short, medium, or long term forecasts. The accuracy of the output depends entirely upon the accuracy of the forecasted growth rates.

System average growth rates. This option could also be used if the historical data was unreliabile. It is applicable to short, medium or long term projections. The average growth rates are either inputted or computed internally. This option could not be used if a high degree of accuracy was needed.

Exponential-smoothing Routine. Exponential smoothing is very sensitive to the latest data. It is applicable only to short and medium term projections. The reliability of the projected demand is highly dependent

upon the reliability of the historical data used. Due to its mechanical nature, the projection's confidence interval widens rapidly.

Least squares method. The least squares method can be used for medium and long term projections. This method utilizes a trend line and thus seasonal, cyclical, and accidental variations are not accounted for. The determination of the trend line is strictly a mechanical process. Again, the accuracy of the projection is dependent upon the reliability of the past historical data.

Geometric progression method. This method can be used for medium and long term projections. Just as in the least squares method a trend line is utilized, although a geometric rather than an arithmetic one. The technique employed is naive as the curve fitting is mechanical. The accuracy of past historical data is a vital determinent of the accuracy of the projection.

Multilinear regression method. Both medium and long range forecasts can be made with this technique. The technique analyzes the average causative or associative joint relationships of one or more independent variables upon the dependent variable. Such determinents as economic, social, political and demographic factors can be evaluated and their effects can then be projected into the future in order to estimate demand. The technique could be either barometric or analytical depending on

whether the relationships were causative or associative. Also, whether the series was leading or not.

Econometric routine. This method can be used for making medium or long term forecasts. Three sub-analyses (macro, secular, and micro) are applied to city-pair traffic demand. These sub-analyses are weighted in terms of their statistical significance and combined to form a single composite forecast. The macro-analysis employs multiplicative multilinear regression; the secular-analysis uses the geometric progression routine; and the micro-analysis uses multiplicative multilinear regression also.

Lockheed air cargo growth study, MRS-49.[19]

Lockheed-Georgia Company has been very active in forecasting intercity air cargo demand. MRS-49 is the first of four Lockheed forecasts to be classified. This forecast is a projection of past trends. A curve was fit statistically to the past data to obtain the trends. The forecast was concerned with the entire free world air cargo although some smaller sections were included. The period of interest actually falls into the medium range category. The forecast extended over a decade and the cyclical, seasonal, and accidental variations were not considered. The material forecasted was revenue ton-miles. The forecast of free world air cargo is shown in Figure 2.4.

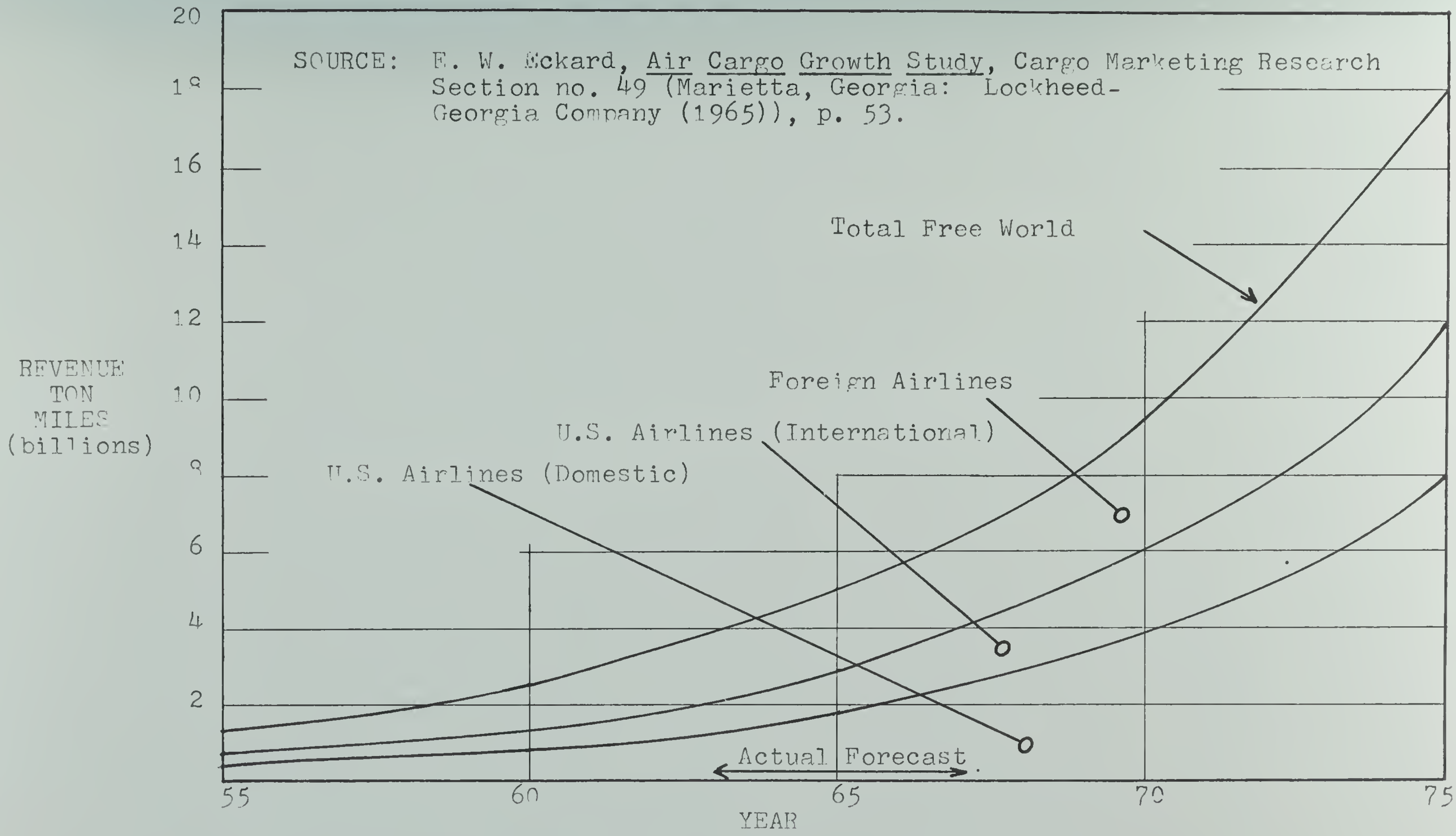


Figure 2.4 Lockheed MRS-49 Free-World Air Cargo Forecast

Lockheed rate elasticity forecast, CMRS-59[21]

CMRS-59 uses the MRS-49 forecast as a base. This forecast, however, added an analytical aspect to the method. By studying past data it was determined that a one percent decrease in average yield would result in a three percent increase in revenue ton-miles. The average yield was forecast and the results of MRS-49 were adjusted accordingly. The scope and type of material forecast did not change. The horizon was extended to include long term. The effect of the rate elasticity adjustment can be seen in Figure 2.5. The CMRS-59 forecast of free world air cargo is shown in Figure 2.6.

Lockheed belly cargo forecast, CMRS-169[22]

CMRS-169 is an update of CMRS-59. The forecast is concerned with free world belly cargo only. The forecast began with the predictions of revenue passenger-miles. From these the passenger fleet mix was predicted. Historical cargo load factors and standard capacities were then combined with the fleet mix prediction to arrive at the belly cargo forecast depicted in Figure 2.7. Although the procedure is rather involved it is still basically an extrapolation of historical data. It is also applicable to medium and long term planning. The dip in the 1980's is due to the projected introduction of the SST which carries no cargo.

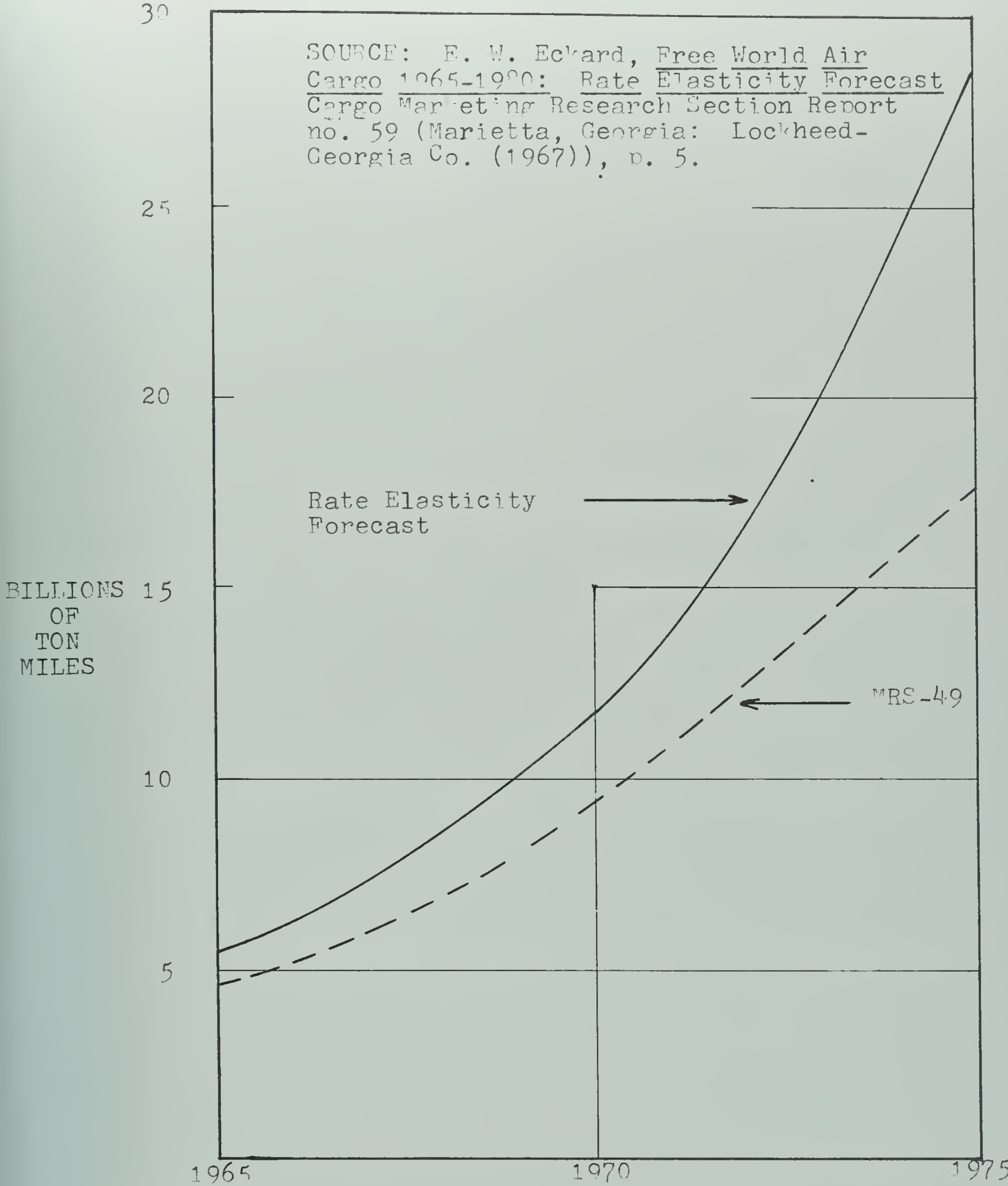


Figure 2.5 Lockheed Rate Elasticity Forecast vs MRS-49 for Free World Air Cargo Volume

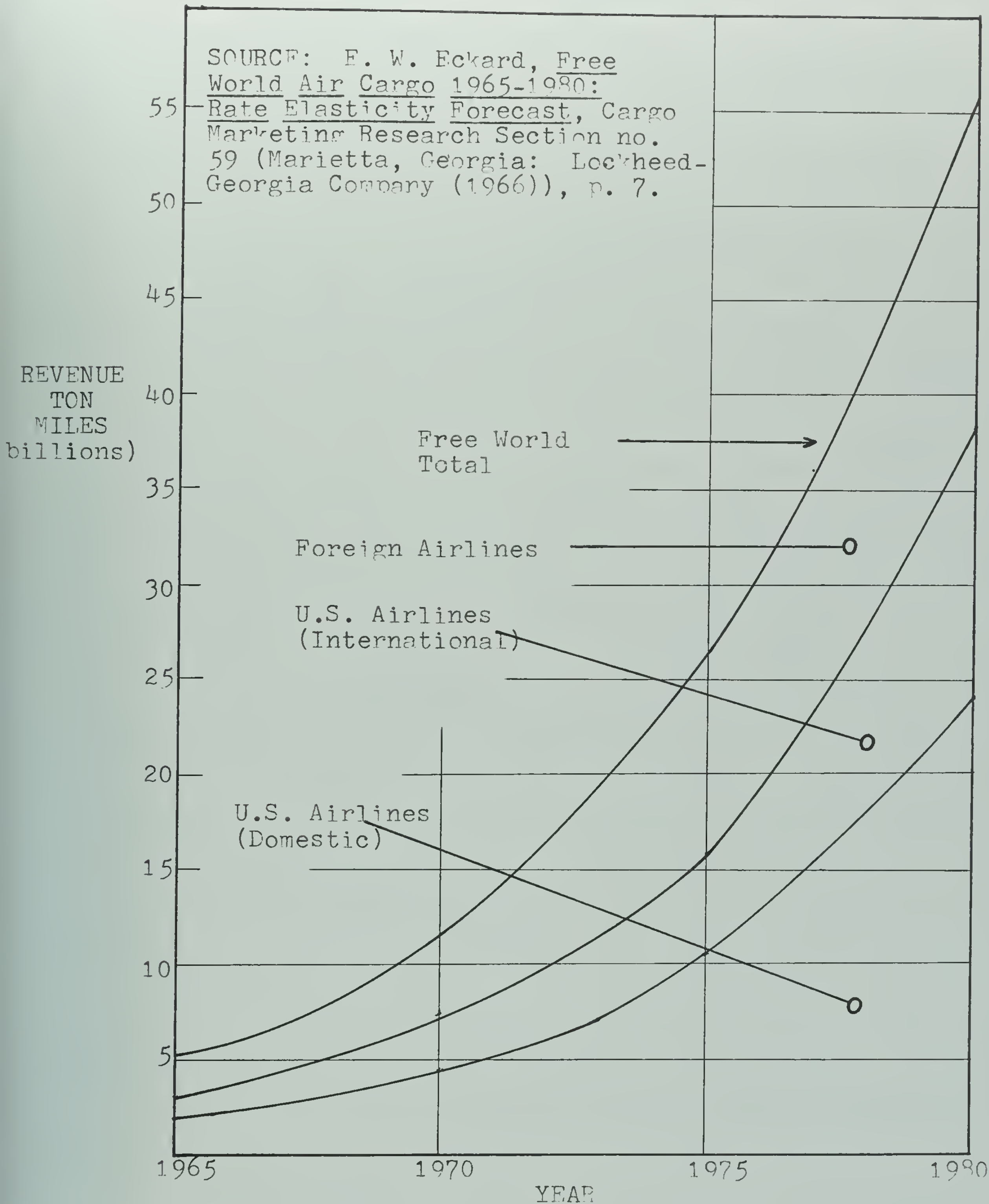


Figure 2.6 Lockheed CMRS-59 Free-World Air Cargo Forecast

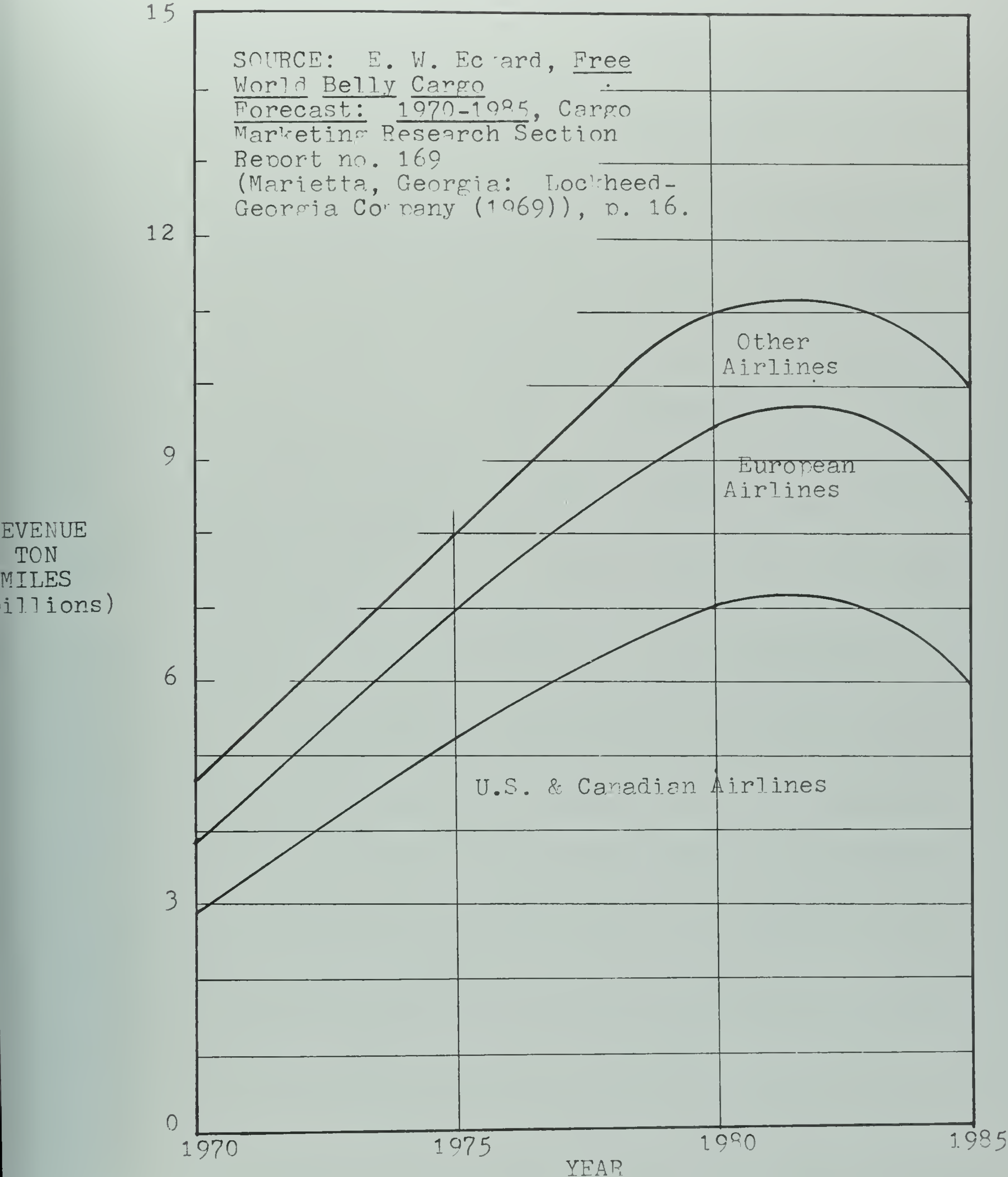


Figure 2.7 Lockheed Belly Cargo Forecast

Lockheed air cargo growth study, CMRS-99[20]

CMRS-99 is an update of CMRS-59. Using statistical projection of past trends plus judmental factors and the rate elasticity formula, free world air cargo was forecast. This forecast is also applicable to medium and long term planning. The forecast contains breakdowns of domicile of airline, class of cargo, geographical area, and method of carriage. Figure 2.8 depicts the free world air cargo forecast by domicile of airline and Figure 2.9 projects what methods of carriage will be used.

Stanley H. Brewer, The North Atlantic Market[43] and The Europe-Asia Market[24]

Professor Brewer developed a new approach to forecasting. He projected population, GNP, and industrial production. From these projections and past relationships he forecasted foreign trade which was broken down and analyzed in groups. From the analysis a potential air freight demand was derived. The potential is based upon the dollar value per pound. Portions of Brewer's two forecasts are contained in Figures 2.10 through 2.13. These forecasts are primarily medium and long term and the material forecasted is revenue ton-miles. Of interest in these forecasts is the elasticity of demand with respect to price that is depicted. It is seen that the North Atlantic market is much more elastic than the Europe-Asia market.

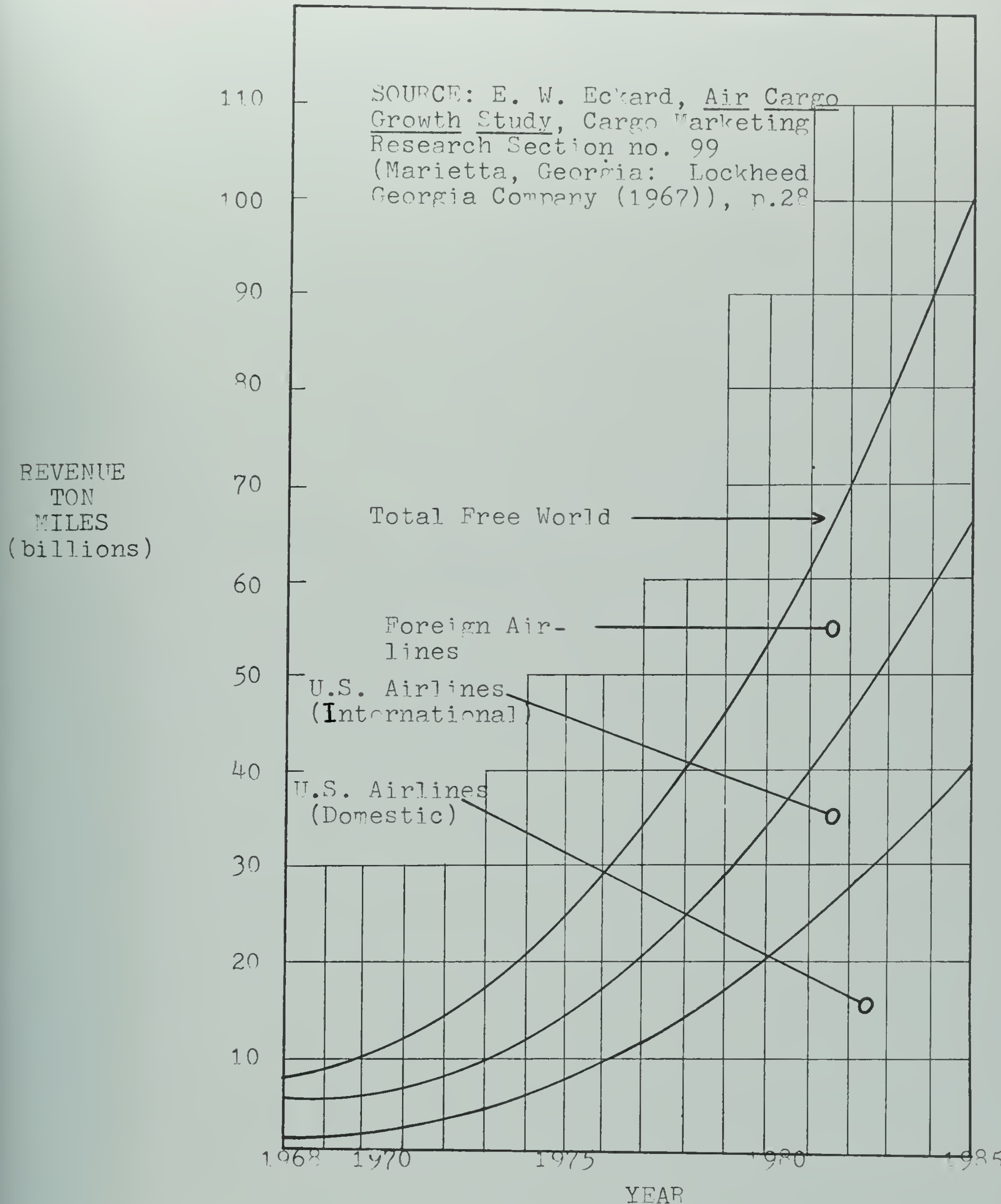


Figure 2.8 Lockheed CMRS-99 Free-World Air Cargo Forecast by Domicile of Airline

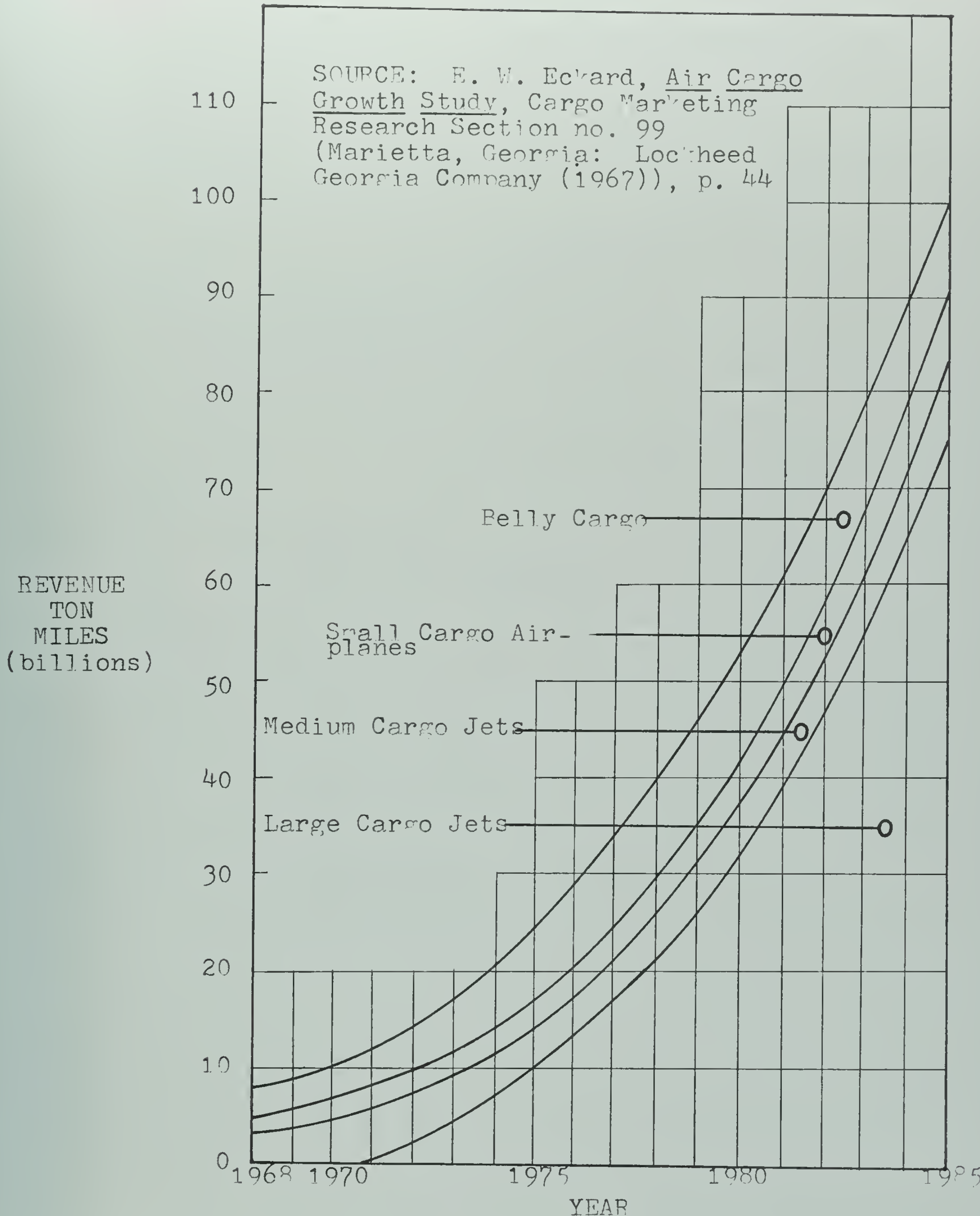


Figure 2.9 Lockheed CMRS-99 Free-World Air Cargo Forecast by Method of Carriage

STANLEY H. BREWER NORTH AMERICA TO EUROPE DEMAND FORECAST

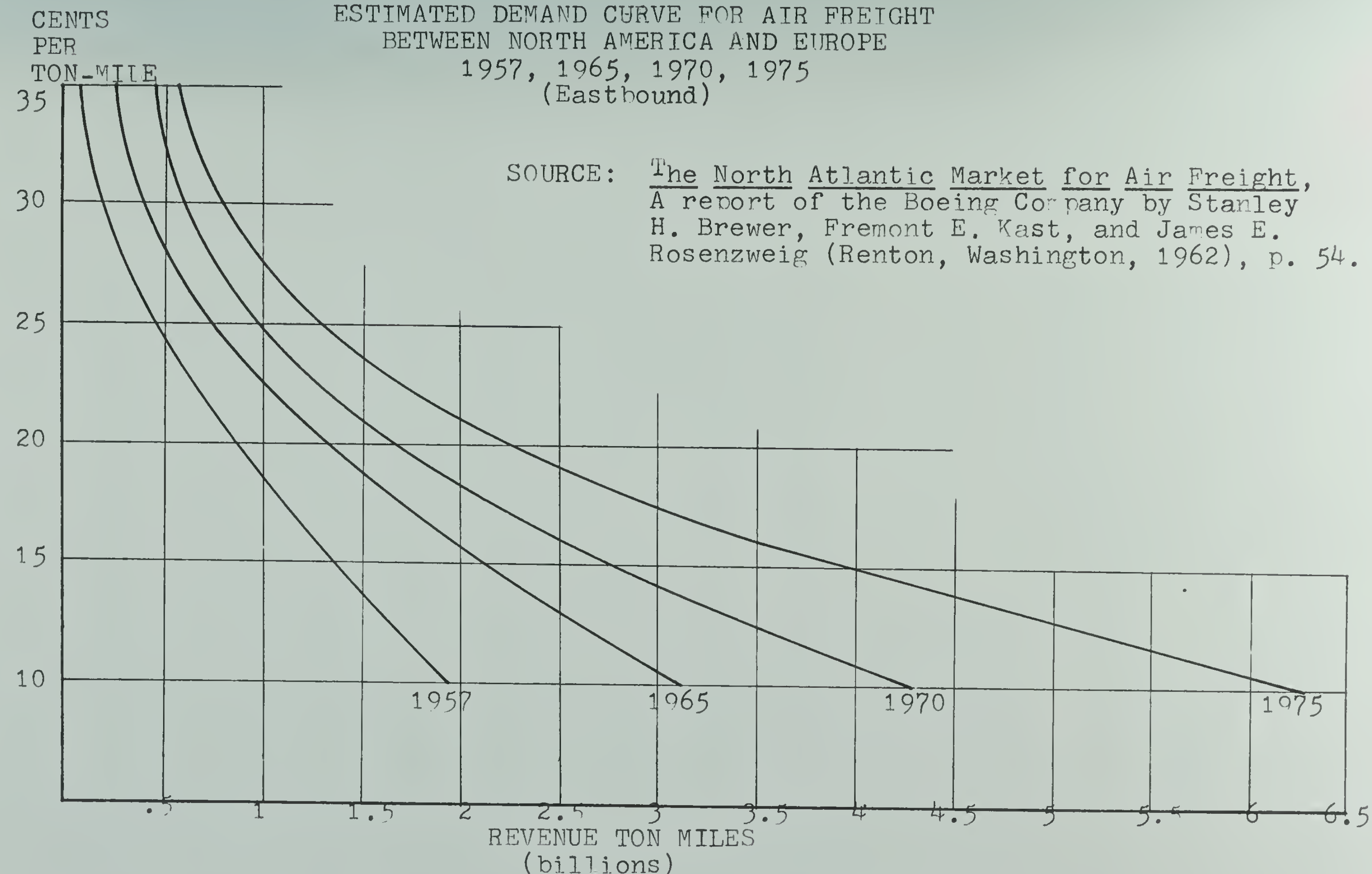


Figure 2.10 Stanley H. Brewer North America to Europe Demand Forecasts

ESTIMATED DEMAND CURVE FOR AIR FREIGHT
BETWEEN NORTH AMERICA AND EUROPE
1957, 1965, 1970, 1975
(Westbound)

SOURCE: *The North Atlantic Market For Air Freight*, A report for the Boeing Company by Stanley H. Brewer, Fremont E. Kast, and James E. Rosenweig (Renton, Washington, 1962), p. 55.

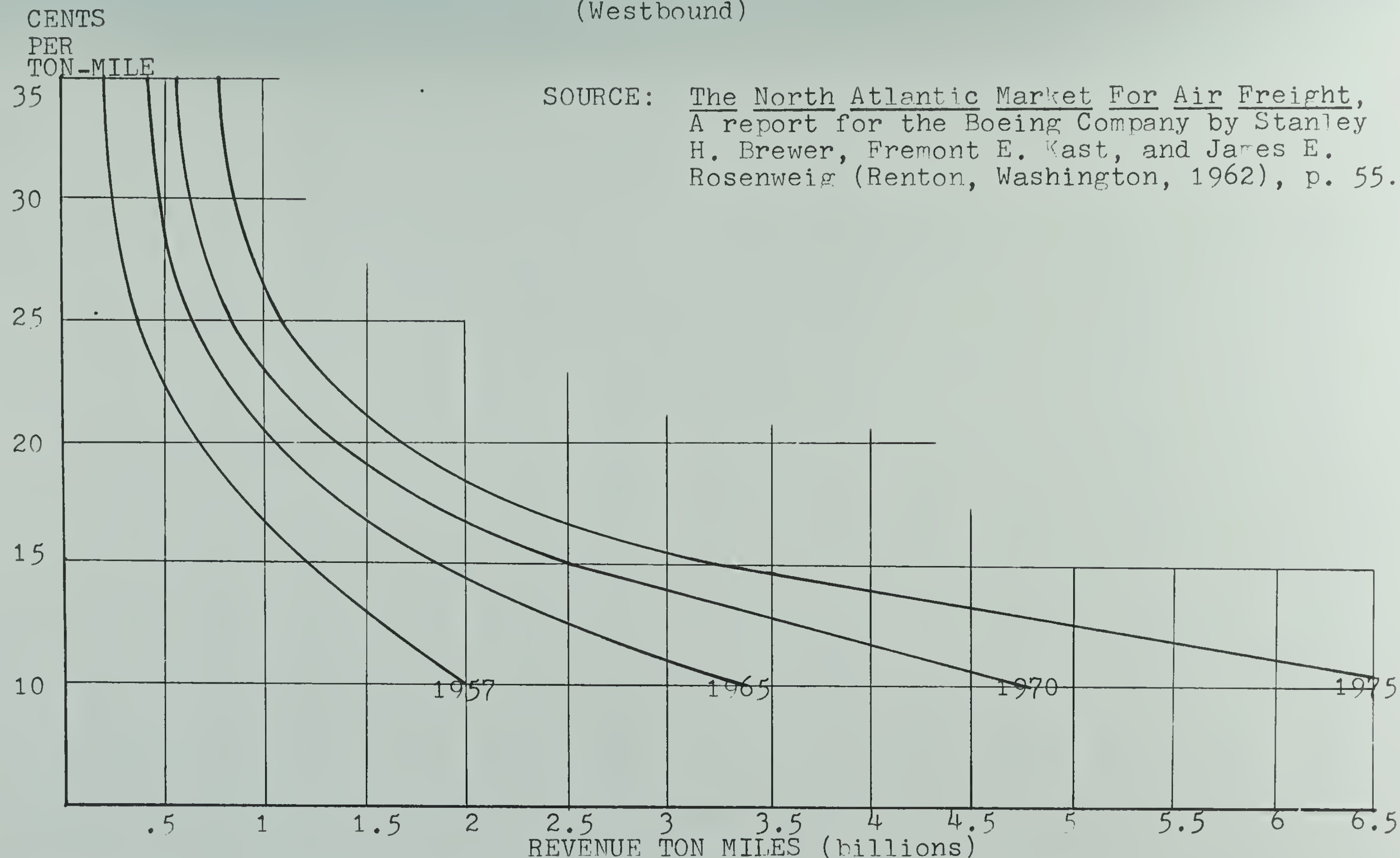


Figure 2.11 Stanley H. Brewer Europe to North America Demand Forecast

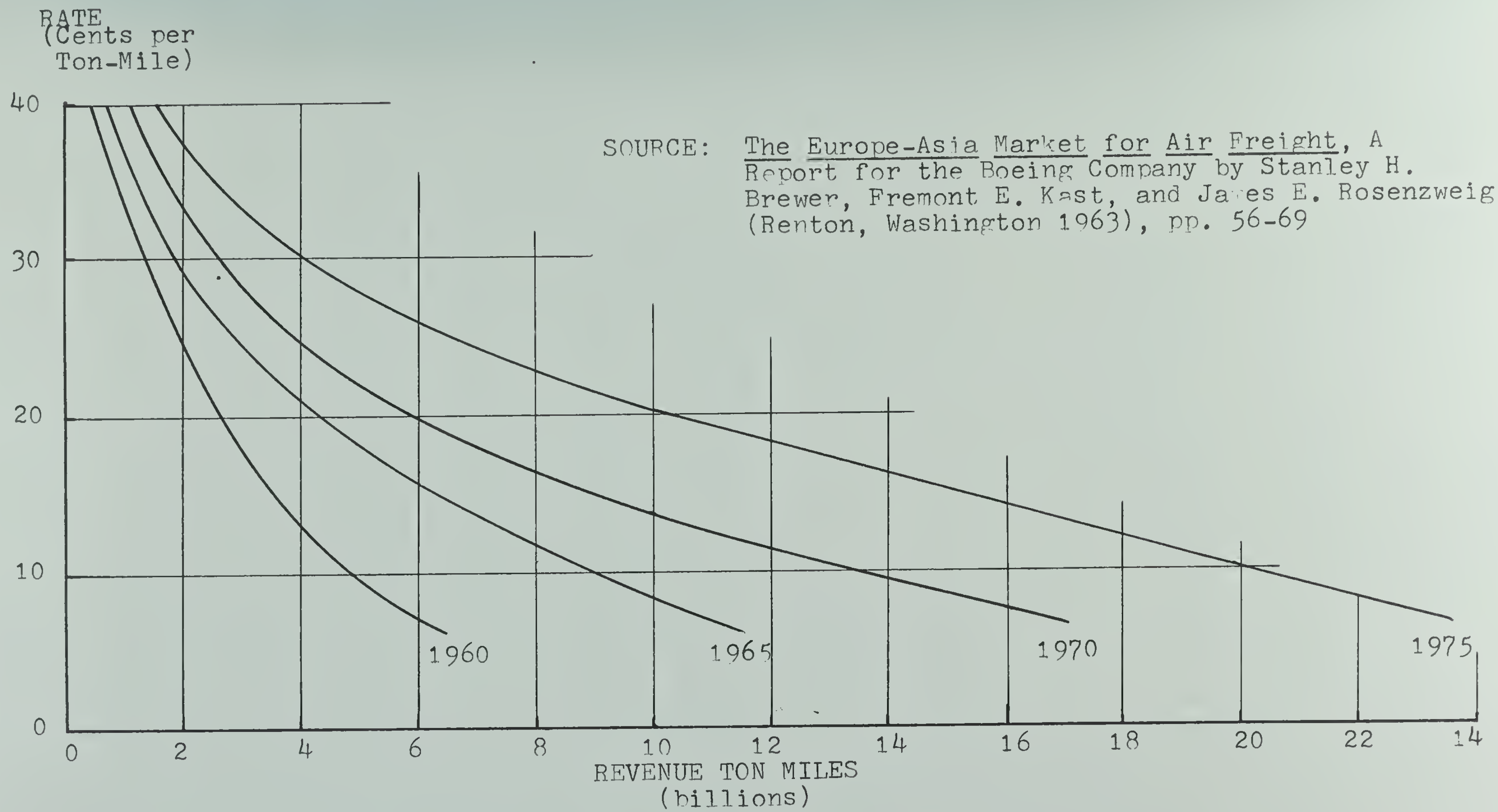


Figure 2.12 Stanley H. Brewer Europe to Asia Demand Forecast

SOURCE: The Europe-Asia Market For Air Freight, A Report for the Boeing Company by Stanley H. Brewer, Fremont E. Kast, and James E. Rosenzweig (Renton, Washington 1963), pp. 56-59

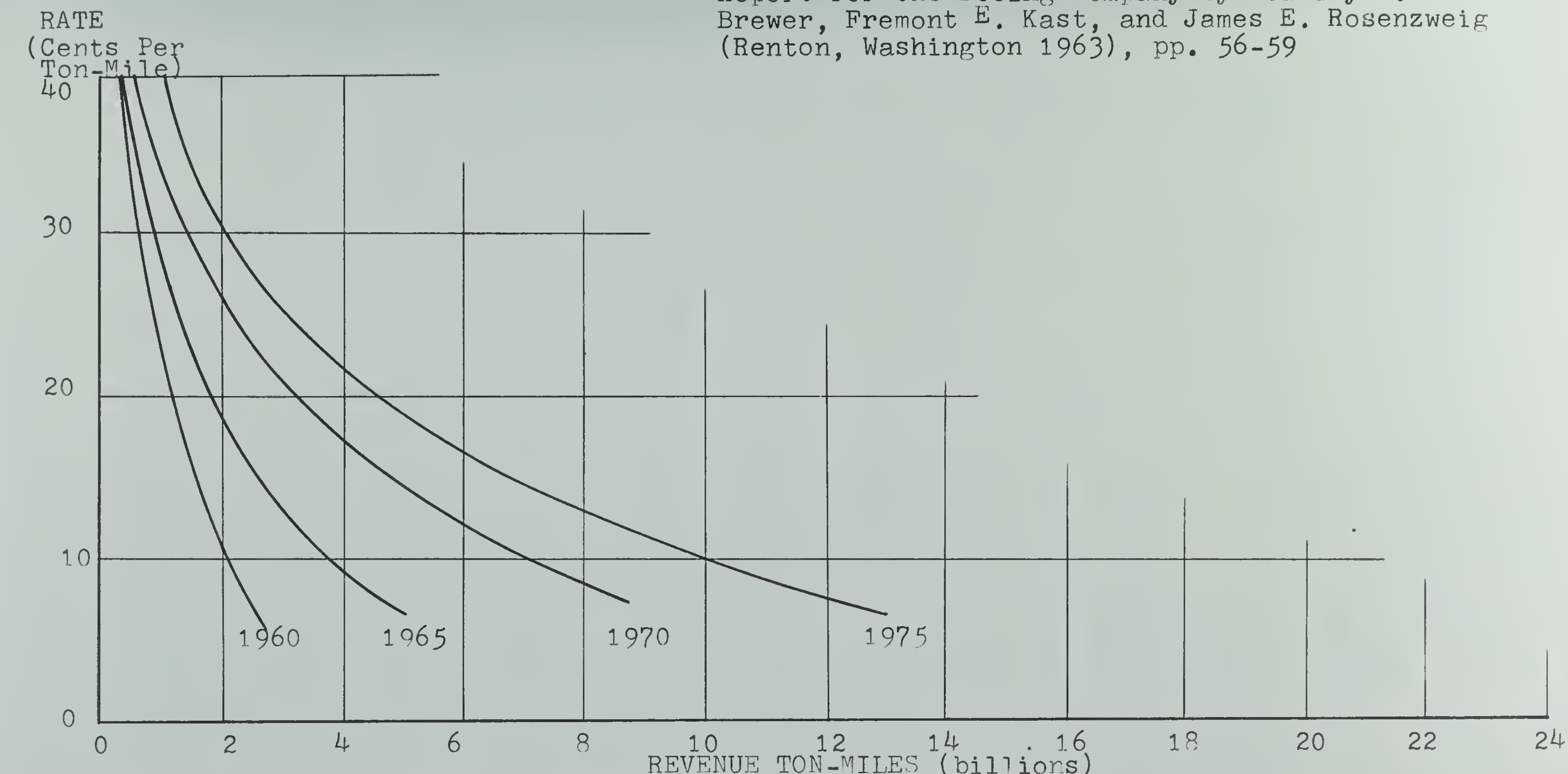


Figure 2.13 Stanley H. Brewer Asia to Europe Demand Forecast

Boeing traffic forecast[8]

This forecast arrived at its predictions in Figure 2.14 solely through trend projection. For the U.S. domestic market two different trends are used for high penetration and low penetration. The forecasts are extremely broad, free world air cargo, and are useful only for gross medium and long term planning purposes. The standard commercial data, revenue ton-miles, are the material forecast.

Resources in America's Future[36]

The technique adopted in this forecast is unique. Requirements for metals, energy, farm products, timber, water, and outdoor recreation are projected based on their relationships to such factors as population and GNP. The forecasting of transportation demand is really an interim step. After projecting a general picture of the U.S. economy (population, GNP, labor force, etc.) consumption levels for food, clothing, transportation, etc., are developed. From this demand for intermediate items are derived and then final demands for resources are determined. Historical modal shares and trends are applied to the gross cargo transportation demand. The forecast of revenue ton-miles for the U.S. is good only for long-term planning. The projections are shown in Table II. High, medium and low projections were made.

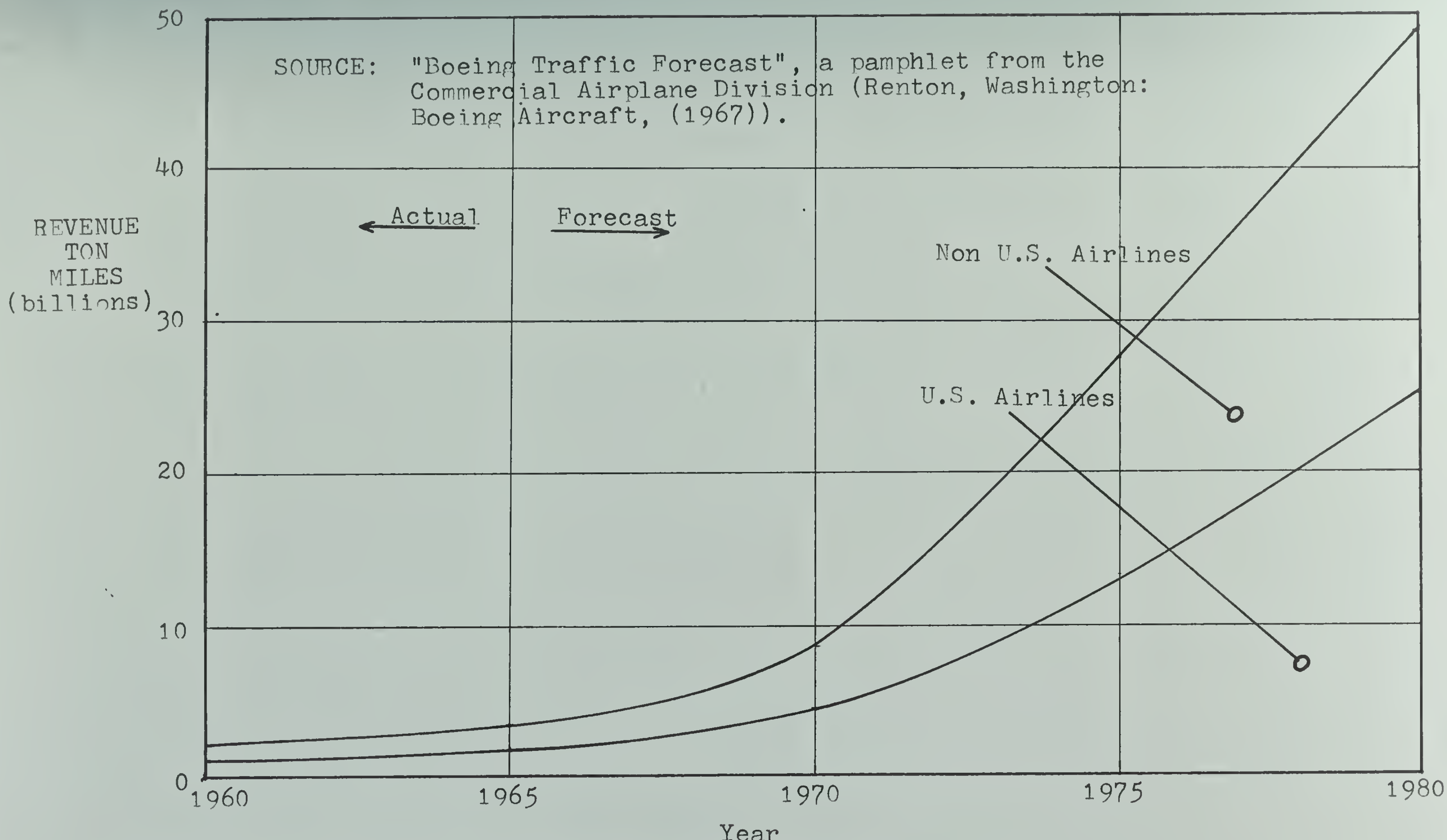


Figure 2.14 Boeing Free-World Air Cargo Forecast

TABLE II PROJECTED VOLUME OF DOMESTIC INTERCITY FREIGHT TRANSPORTATION, BY TYPE OF CARRIER[1]

	1950	1955	1960		1970	1980	1990	2000
Rail ton-miles[4] (billions)	597	631	579	L	592	611	653	755
				M	738	912	1,179	1,593
				H	929	1,394	2,058	3,192
Truck ton-miles[4] (billions)	173	223	299	L	375	526	729	974
				M	489	753	1,125	1,671
				H	604	1,119	1,967	3,192
Inland waterway ton-miles[4] (billions)	163	216	223	L	257	306	380	487
				M	317	447	630	900
				H	399	663	1,049	1,702
Air ton-miles[5] (billions)	.33	.49	.69	L	1.25	1.70	2.10	2.30
				M	1.45	1.70	4.60	6.30
				H	1.70	4.[illegible]0	10.30	25.30

SOURCE: H. H. Landsburg, L. L. Fischman, and J. L. Fisher, Resources in America's Future (Baltimore: Johns Hopkins Press, 1963), p. 651.

A.T.A. Executive Summary[2]

The Air Transport Association (ATA) used a combination of trend projection, multiple correlation, and a factor which measures both price and quality of service for domestic freight. For the remaining categories only trend projection was used to arrive at the revenue ton-miles graphed in Figure 2.15. The forecast has application to medium and long term planning.

Arthur D. Little, Inc.[16]

The Arthur D. Little projections are best estimates based on an evaluation of all relevant factors. They project a 13% annual growth for domestic air cargo and a 15% annual growth for free world air cargo for the next 10 years. They base their figures upon insight gained while trying to build on econometric model of intercity air cargo demand.

Richard Lawson[58]

Mr. Lawson fitted a multiple regression curve based on time, coal usage, Industrial Production Index (IPI), population, and GNP. The forecast is a medium term projection of revenue ton miles for all modes in the U.S.

A. H. Norling[42]

Mr. Norling has simply extrapolated the trends of various ratios into the future. The results are useful only for gross long term planning. The revenue ton-miles that he projected for U.S. intercity freight ton-miles are not broken down by modal share.

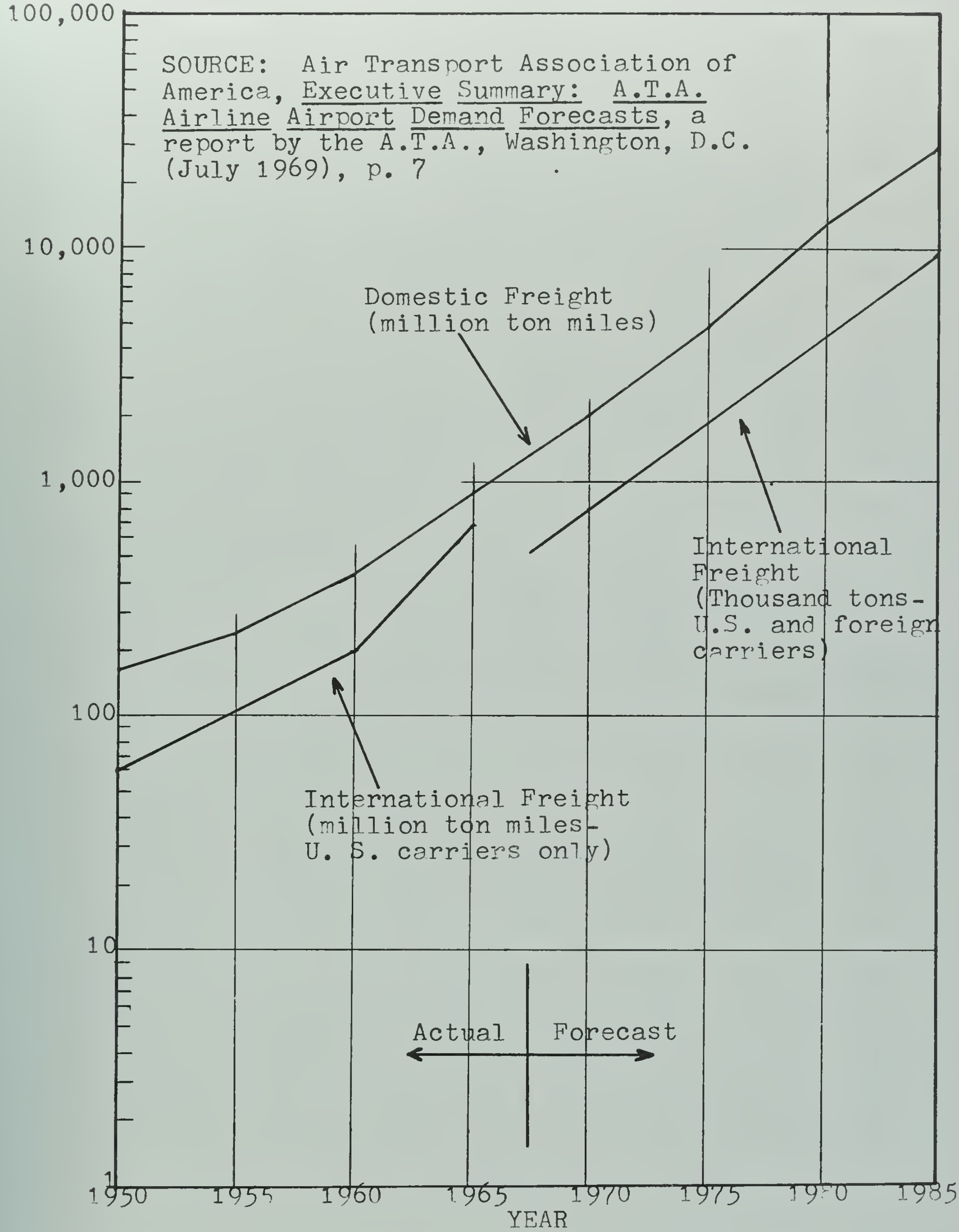


Figure 2.15 A. T. A. Domestic and International Freight Forecasts

United Aircraft Corporation[17]

In this forecast long term trends were analyzed and projected. The projections were then dis-aggregated to originations and terminations at the most important air terminal cities. The forecast of domestic cargo is contained in Figure 2.16. The data can be used for both medium and long term planning. Both revenue ton-miles and operational data are forecast.

Interavia[1]

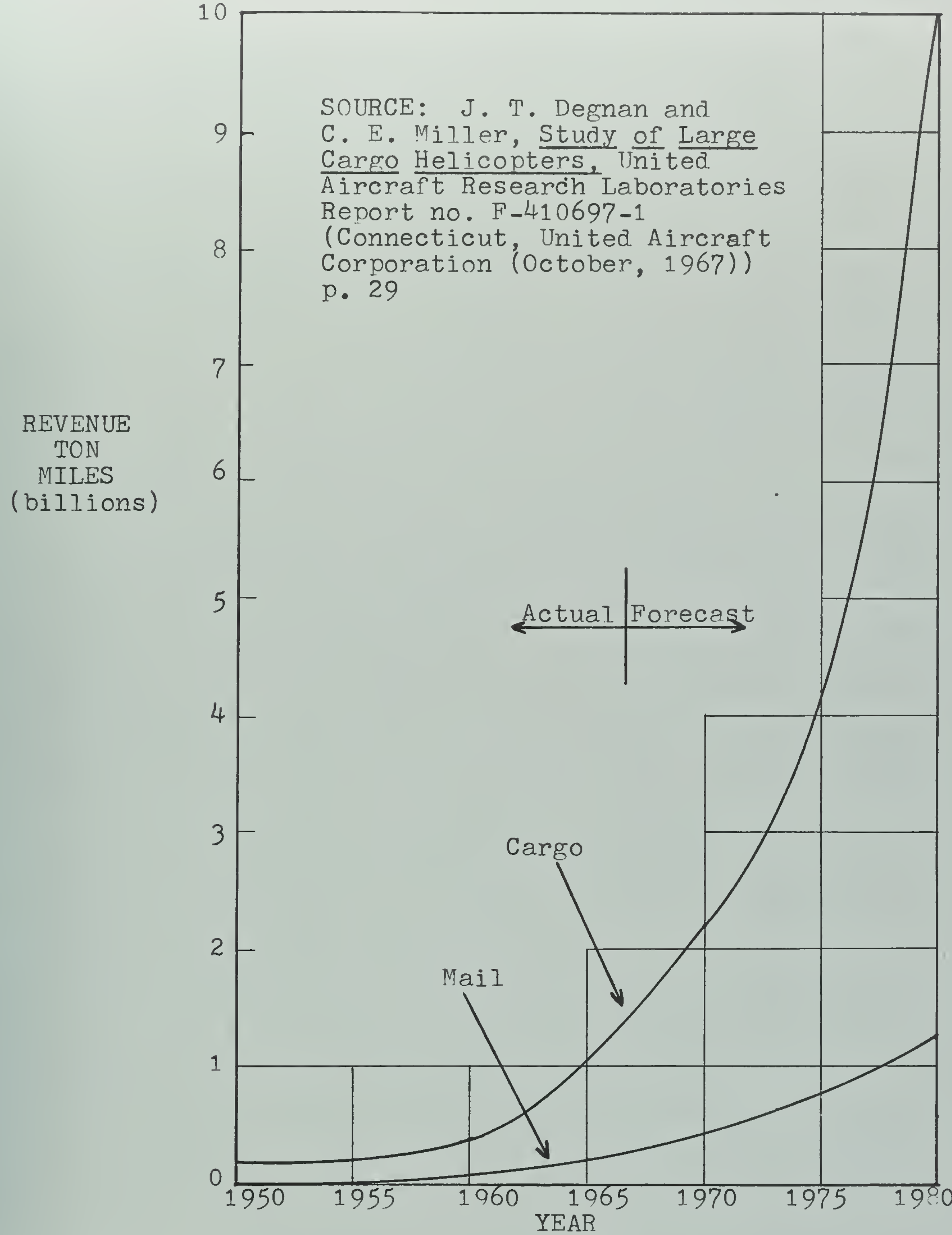
The Interavia forecast represents a consensus as to the most likely trends. As variations are not included only medium and long term forecasts of world ton-miles are possible..

W. A. Jessimam[34]

The forecasting method described in this article is, in the words of the author, "only useful where highly accurate forecasts are not required or where the forecast year is not far removed from the base year." The inaccuracy and time limitation would seem to allow only medium term forecasts. The method uses past trends obtained through regression. It forecasts revenue ton-miles at air transportation hubs.

Karen R. Polenske[46]

A method which would seem to have wide applicability is the input/output table. It requires a careful analysis



gure 2.16 United Aircraft Domestic Air Cargo and Mail Traffic Forecast

of past data and can forecast into any time horizon. It can operate on single hubs, networks, or vast geographical areas. It can forecast revenue ton-miles for all modes or split into modal shares. This method has not been used to date in this regard (at least not openly). A combination of an input/output table coupled with a transportation model was also described by John E. Harman.[32]

Douglas' Current Outlook[15]

The Douglas forecast is a simple extrapolation of trends. The revenue ton-miles forecast are applicable to medium and long range planning. There is also a forecast of cargo aircraft requirements.

SUMMARY OF CLASSIFICATION OF FORECASTS

		Technique			Scope			Horizon			Material Forecast		
		Naive	Baro-metric	Analyt-ical	Single	Network	Vast	Short	Medium	Long	Commer-cial	Opera-tion	Eco-nomic
FAA Fiscal Year Aviation Forecasts		X					X	X	X	X		X	
FAA Large Air Hub Forecasts		X			X				X	X		X	
MDC Air Cargo Forecast		X					X			X	X		
FORPAC	Inputted rates			X	X			X	X	X	X		
	Average growth rate	X			X			X	X	X	X		
	Exponential smoothing	X			X			X	X		X		
	Least squares	X			X				X	X	X		
	Geometric progression	X			X				X	X	X		
	Multilinear Regression		X	X	X				X	X	X		
	Polynomial Regression		X	X	X				X	X	X		
	Econometric			X	X				X	X	X		
Lockheed MRS-49		X					X		X		X		
Lockheed CMRS-59		X		X			X		X	X	X		X
Lockheed CMRS-169		X					X		X	X	X		X
Lockheed CMRS-99		X		X			X		X	X	X		

Table III

SUMMARY OF CLASSIFICATION OF FORECASTS (Cont'd.)

	Technique			Scope			Horizon			Material Forecast		
	Naive	Baro-metric	Analyt-ical	Single	Network	Vast	Short	Medium	Long	Commer-cial	Opera-tion	Eco-nomic
Stanley H. Brewer	X		X			X		X	X	X		X
Boeing	X					X		X	X	X		
Resources	X		X			X			X	X		
A.T.A.	X		X			X		X	X	X		
Arthur D. Little, Inc.			X			X		X		X		
Richard Lawson	X					X		X		X		
A. H. Norling	X					X			X	X		
United Aircraft	X		X	X		X		X	X	X	X	
Interavia			X			X		X	X	X		
W. A. Jessiman	X			X				X		X		
Karen R. Polenske			X	X	X	X	X	X	X	X		
Douglas	X					X		X	X	X	X	

Table III (Cont'd.)

PART 3

FACTORS AFFECTING AIR CARGO

A. Introduction

An important aspect of forecasting for intercity air cargo is an understanding of the factors that affect air cargo. The relationship between these factors and intercity air cargo may be either associative or causative. An associative factor could be, for example, Gross National Product (GNP). Although it may appear that an increase in GNP results in an increase in intercity air cargo demand the actual cause of the increase is attributed to something else. GNP is simply a measure which is reflecting the increase in air cargo demand. A causative factor is self-explanatory.

These factors can be basically subdivided into 3 categories. The first group is composed of general economic indicators. The next grouping is those factors which bear only on the intercity air cargo industry and on the freight transportation industry. The final category is composed of those factors that operate at the level of the customer. Grouping the factors affecting intercity air cargo in this manner facilitates the understanding of the industry's environment.

B. Classification and Discussion

General Economic Indicators

The general economic indicators that appear to be associated with intercity air cargo and population, GNP, Gross Regional Product (GRP), labor force, goods, and construction, industrial production, coals production, and steel production. These indicators were used by various people and organizations in an attempt to forecast intercity air cargo.

Professor Brewer used population, GNP, and industrial production in his forecast of the North Atlantic market[43] and the Eruope-Asia market.[24] He further stated that while there was a large degree of correlation between these indicators and air cargo for highly industrialized regions it did not hold true for the less industrialized regions.

In "Resources for America's Future",[36] population, labor force, and GNP were used to indicate a general picture of the U.S. economy. GNP was broken down into its many constituent parts and various correlations were tried. A tight correlation was found between intercity freight and GNP less services.

Richard Lawson[58] worked with various combinations of population, steel production, coal production, time, GNP, GNP less services, and the Industrial Production Index (IPI). He found the best regression line was obtained when he

used population, coal production, time, GNP, and IPI. He also found that the correlation was poor between air share and the rest of the freight industry.

A. H. Norling examined the ratios of total intercity freight ton-miles to population, GNP, goods and construction, and IPI. He found that they all gave acceptable correlation.[42] E. W. Eckard in CMRS-99 related the increase in intercity air cargo to the growth in GNP.[20] Conversely, B. A. Schriever and W. W. Seifert found that while total domestic freight traffic was closely correlated with disposable personal income and GNP, domestic air freight traffic growth rates varied greatly in relation to the growth in GNP.[49]

Population and GRP were the economic indicators used in the macro-economic model of Volume I of the "Studies on the demand for freight transportation." It was noted that the variables used were not necessarily the best but rather served as an example of the construct which appeared appropriate.[59]

These economic indicators then, provide a starting point for forecasting intercity air cargo. They set the environment within which the industry is operating. Such indicators are associative factors. That is, as illustrated earlier, while an increase in one of the indicators may be paralleled by an increase in intercity air cargo,

the increase in air cargo is not caused by the indicator's increase. In addition, the macro-economic indicators would not seem to lend themselves to an accurate indication of demand on a smaller scale. That is, GNP would not seem to be a good indicator of air cargo at the Atlanta transportation hub or, if Schriever and Seifert are correct, on a national scale as well.

Industry factors

There are many factors affecting intercity air cargo demand which can be considered as being within the industry. This may be because the industry has exclusive control over them or because they affect only the industry. These factors are all causative factors and may well be termed determinents of demand. These factors interact greatly with each other and it is impossible to neatly segregate any of them at any time. A thorough understanding of their relationships is necessary for effective forecasting for intercity air cargo.

Probably the most important factor affecting intercity air cargo is the cost to the customer, the rate structure. This can best be described by dealing with the price-elasticity of demand. What would be the effect on demand if the cost per ton-mile were reduced?

W. B. Allen determined that the demand is elastic with price. That is, if the cost to the customer were

reduced the demand for air cargo would increase. He was unable to test his model with a domestic application. He stated that "such functions would be immensely useful to the industries involved and to regulatory bodies. At the present time, these bodies make rate decisions on the basis of evidence on demand elasticity that is obtained by the application of questionable techniques to inadequate data."[4]

William Cotterman reached a slightly different conclusion. He stated that "the elasticity of demand with respect to own price is unity in the case of the trunk carriers and inelastic in the case of both the local service and the all-cargo carriers."[13]

Lockheed introduced a rate-elasticity factor into their forecasts in 1966. From an examination of past data they determined that for every one percent decline in average yield a three percent increase in cargo volume resulted. They made no distinction as to type of carrier.[21] In 1967, Lockheed determined that their rate-elasticity equation still was valid.[20]

Henry McKinnell, Jr. hypothesized that the total demand for air freight services was a negative function of the general level of air freight rates. He determined at the conclusion of his study that there was a high price elasticity of air freight demand.[40]

Professor Brewer found varying degrees of price-elasticity of demand in his North Altantic forecast. In Figure 2.12 it is seen that the market is elastic. However, breaking the market into segments shows that the United States to Europe market, Figure 3.1, is very elastic, while that from Mexico and Canada, Figures 3.2 and 3.3, is inelastic.

There is a second concept which is being widely endorsed from the air cargo side and must now gain favor with the customer. This is the total cost of distribution concept. W. D. Perreault advocated this total cost of distribution concept in his speech at the 1970 International Conference of Air Cargo in the Next Decade.[45] Comparing rate structures, air cargo cannot compete with the other modes of freight transportation. Air cargo rates are consistently much higher than those of other modes. The idea was presented that cost comparisons should not be made on the basis of rates alone but should be the total cost to the customer. An advantage of air cargo is its speed. With this additional speed the product being transported takes less time to get from point A to point B. The customer has less in-transit inventory and thus is saving over other modes. There is also the point that there is ~~also~~ less cost of damage, pilferage, loss, or perishability with air cargo and this is another savings for the customer. The abstract mode model of

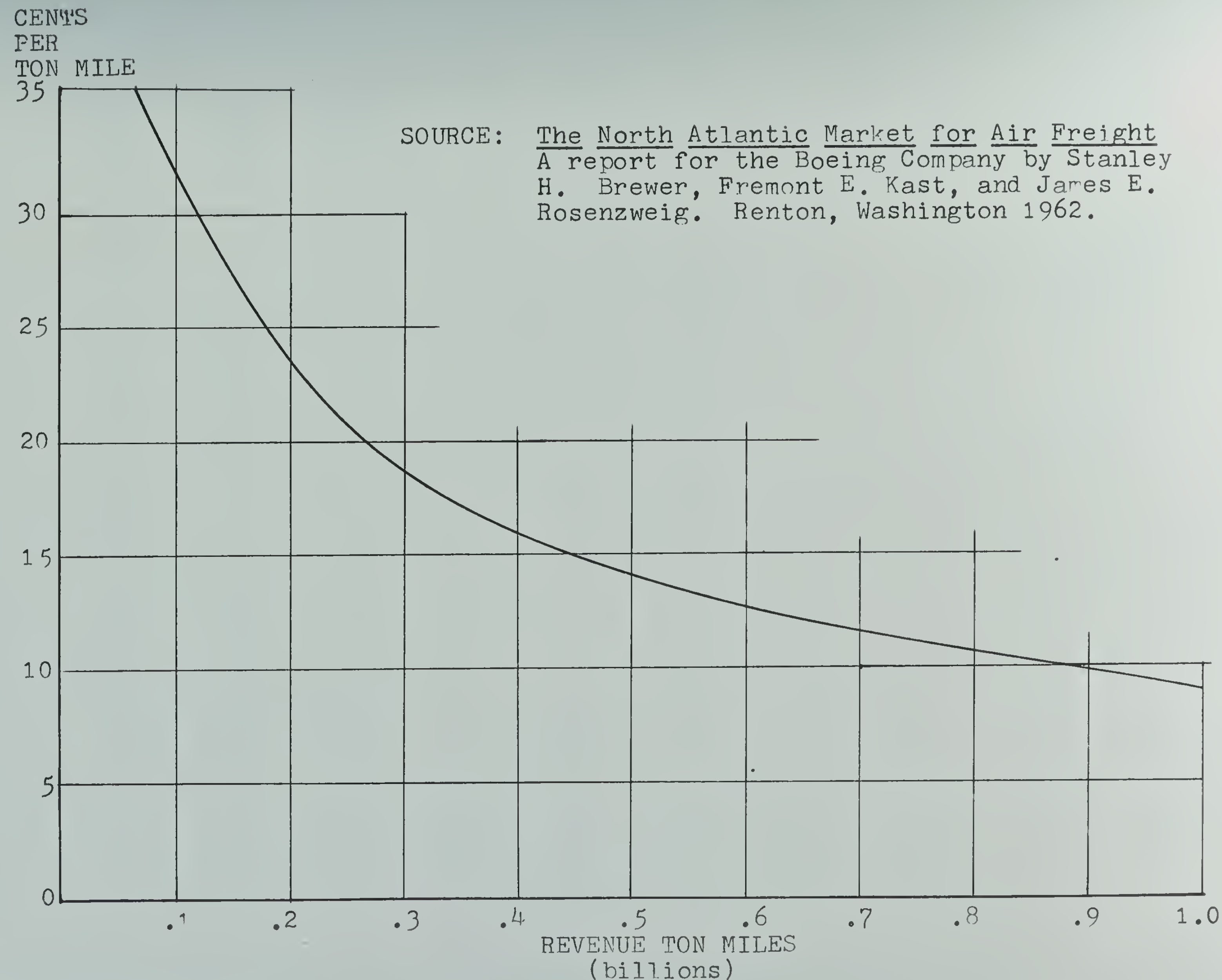
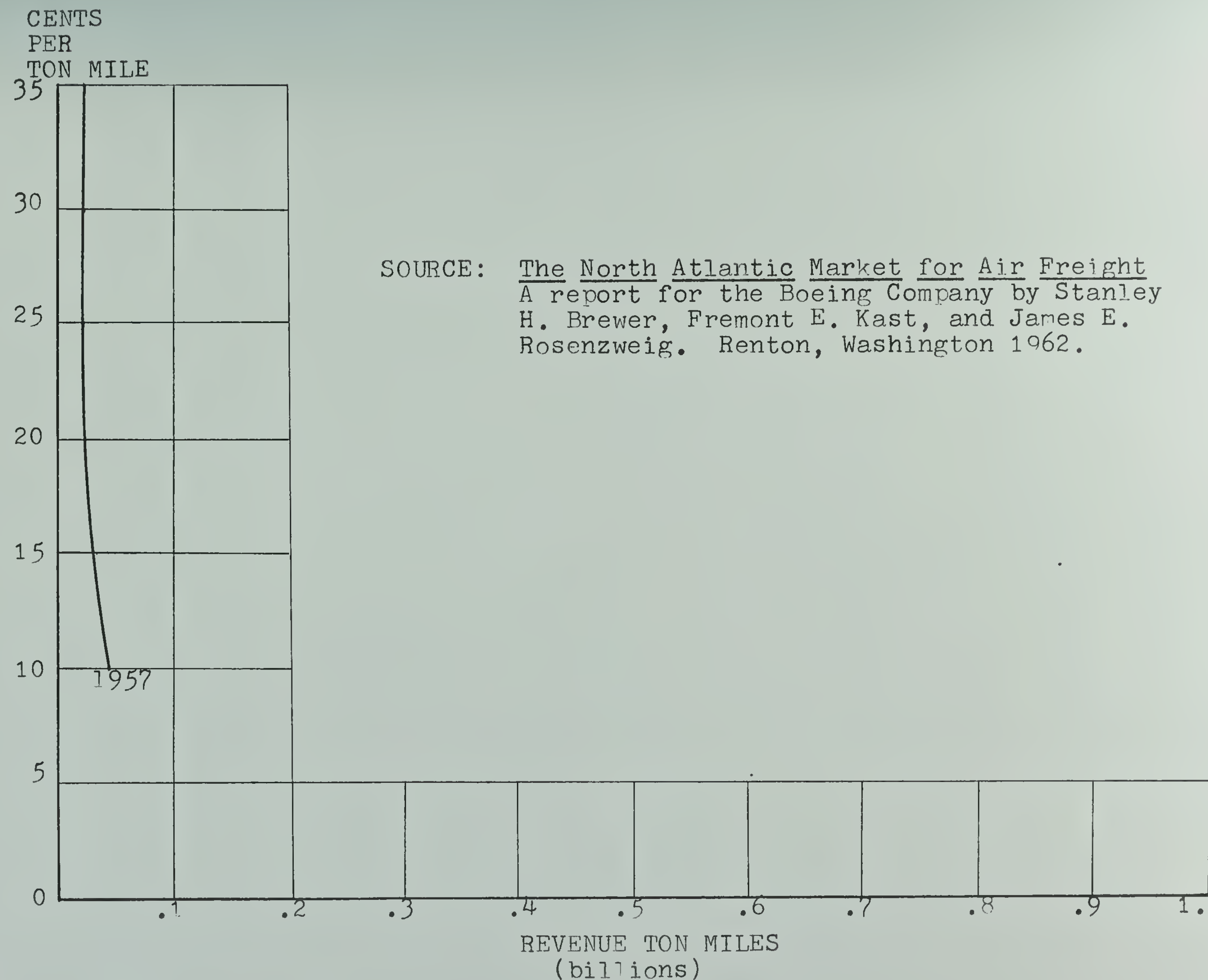
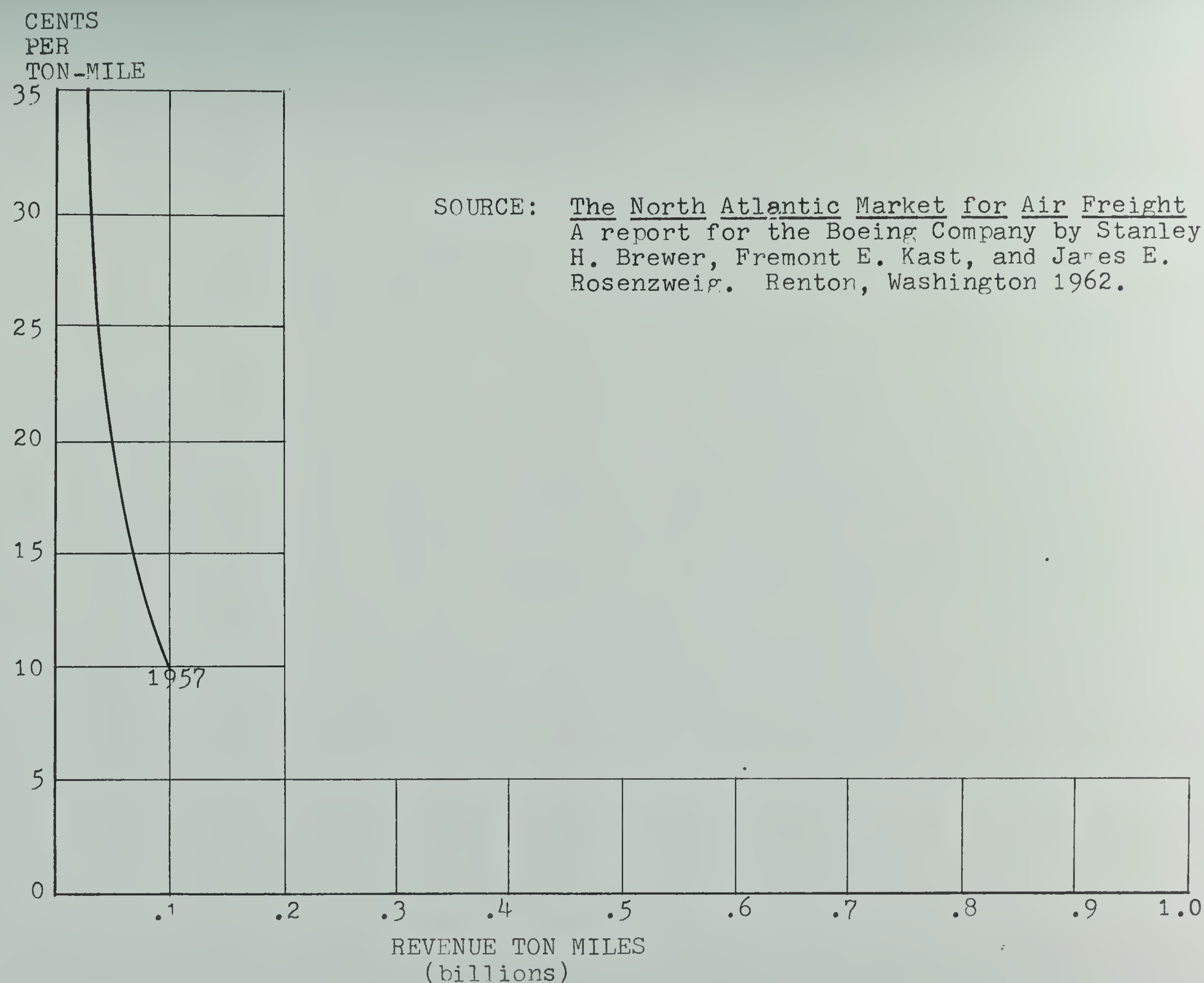


Figure 3.1 Stanley H. Brewer Demand Curve for Air Freight from the United States to Europe-1957



SOURCE: <u>The North Atlantic Market for Air Freight</u> <u>A report for the Boeing Company</u> by Stanley H. Brewer, Fremont E. Kast, and James E. Rosenzweig. Renton, Washington 1962.

Figure 3.2 Stanley H. Brewer Demand Curve for Air Freight from Mexico to Europe-1957.



SOURCE: *The North Atlantic Market for Air Freight* A report for the Boeing Company by Stanley H. Brewer, Fremont E. Kast, and James E. Rosenzweig. Renton, Washington 1962.

Figure 3.3 Stanley H. Brewer Demand Curve for Air Freight from Canada to Europe-1957

the Northeast Corridor Project employs shipping cost/unit, mean shipping time, variance in shipping time, and carrying cost/unit of time.[59] The interest rate has also been applied in some cases to define an opportunity cost caused by having to maintain excess in-transit inventory.

Another important factor that is often ignored is the type of service provided. Service is defined as the routes flown and schedules of flights (both timing, and number). The better the service is from the customers' point of view the more likely that he will use air freight.

Douglas Aircraft incorporated a service factor into the penetration portion of their forecast.[18] G. Besse notes that quality of service may have either a positive or negative effect on demand.[7] Lockheed stated that as service increased so did demand.[20] Such items as pilferage or loss could be handled under quality of service but they are already taken care of under the total-cost concept.

The equipment being used has an impact upon air cargo demand. Limitations on route distances, shipment size and weight, and intermodal capability could easily lower demand. Henry McKinnell, Jr. concluded that the past growth in the industry was partly due to technological innovation and continuing growth will require high investment in the industry.[40] Lockheed has interjected the impact of new

jets into its forecasts.[20] "Resources in America's Future" predicted that if large economical air freighters were developed, air transport could become of considerable importance for certain types of traffic.[36] R. W. King feels that the future of air cargo transportation is directly related to containers.[35] The Institut du Transport Aérien (ITA) cautions that the introduction of new flight equipment and facilities must be taken into consideration when making forecasts.[7] David H. Reeher states that the airlines' acquisition and use of the large-capacity subsonic jet transports in the 1970's is an important element in the industry's future.[47]

Of the many sources examined only four discussed a factor that could invalidate all intercity air cargo forecasting attempts. That factor is the effect that capacity has had on demand. Has a shortage of capacity held down demand? Simat, Helliesen, and Eichner, Inc. consider it in their study of air cargo and air passenger terminal facilitation.[53] Henry McKinnell, Jr. tried to determine what effect supply had on demand but could only conclude that supply was a factor.[40] Lockheed asks if possibly growth was only limited by capacity during the past decade.[37]

Another factor is competition. If the competing modes would stagnate then improvements in the air cargo

industry would have easily predictable results. However, the other modes are improving also. "The future volume of air freight will depend not only on changes in general economic conditions and the extent of technological advances within the air industry but also on the future cost levels and services patterns of competitive forms of transportation."[11] Mr. McKinnell incorporates into his model a positive function of the general level of rates of competing modes.[40]

The organization of the industry itself is a factor. Consideration must be given to the general organization of transport, government policies, airline structure, etc.[7] How well the industry plans is important. "While the potential of the air freight industry is large, it is essential that much attention be directed to the economic as well as the technical aspects of the industry. Too often in the past airlines have concentrated on the design of aircraft and ground support equipment while failing to organize and systematize the industry to enable full exploitation of the potential economic advantages inherent in the industry. There is a particular need to develop a more rational rate structure than presently exists and to identify in more definitive terms specific markets for air freight operators.[11]

Customer factors

There are certain factors over which the air cargo industry has no control. These are factors describing the customer which at the same time affect demand.

An important consideration is whether the customer's industry is amenable to air cargo transportation. James Gorham presented a set of criteria to be used in determining who is an eligible candidate for air cargo.[31] The criteria are contained in Table IV. Another factor which bears on industry amenability is the product's value, the determinent of whether it can bear the cost of air transportation. The market price of the product is an element of W. B. Allen's model.[4] William Cotterman concluded that one of the characteristics of products shipped by air was their value.[13] Professor Brewer based his forecasts on dollar value per pound.[43]

P. F. Calkins presents another factor and that is product density. Aircraft are generally filled to volume capacity before they are filled to their weight capacity. The reason is the low density of products that move by air. Mr. Calkins predicts that average densities of products that are packed for air shipment will have decreased slightly by 1975.[38]

Another factor is the firm's location. Its location may preclude the use of, or make it more expensive, air cargo. The macro-economic model of the Northeast Corridor

CLASSIFICATION OF AIR FREIGHT USAGE BY REASON FOR USE AND TYPE OF SITUATION

General Use Class	Specific Use Class (reason)	Situation Type
A. Use of speed to reduce time in transit	A.1. Increase sales or improve service in time-limited situations	A.1. Demand in time-limited: a. In a market for time- or style-dated commodities b. In a premium-price market c. In a seasonal or holiday market Market for perishable commodities can be extended: a. In time b. Geographically
	A.2. Increase utilization of production facilities and equipment	A.2. Utilization can be increased for: a. A production unit by reducing time lost while waiting for parts or materials b. A fixed facility by extending supply or market area c. A mobile production facility or equipment by reducing time spent in moving between jobs
	A.3. Reduce company or customer investment in goods in transit	A.3. The company desires to speed up investment turnover in commodities which can be used as soon as received.
	A.4. Meet unpredictable demands and emergencies	A.4. Any situation in which air freight will meet a critical requirement for the shortest possible transit time

Table IV.

CLASSIFICATION OF AIR FREIGHT USAGE BY REASON FOR USE AND TYPE OF SITUATION (Cont'd.)

General Use Class	Specific Use Class (reason)	Situation Type
B. Use of speed to reduce costs of holding goods in inventory while maintaining or improving service	B.1. Reduce inventory investment	B.1. Inventory is used specifically to service production and sales requirement because demand is unpredictable as to time, location, or variety
	B.2. Reduce risk of inventory loss or obsolescence	B.2. Inventory used to service production and sales is physically, technologically, or style perishable and demand is unpredictable
	B.3. Reduce investment and operating expenses associated with inventory facilities and service	B.3. Reduction or elimination of inventory will permit reducing: a. Size or completely eliminating an inventory facility at one or more locations b. Inventory servicing costs even without reducing warehouse facilities c. Inventory can be centralized to permit a reduction in total facilities and servicing costs even without reducing total inventory
	B.4. Reduce costs incurred by having jobbers or wholesalers perform inventory function	B.4. A company's procurement or distribution processes will permit bypassing jobbers or wholesalers

Table IV (cont'd.)

CLASSIFICATION OF AIR FREIGHT USAGE BY REASON FOR USE AND TYPE OF SITUATION (cont'd.)

General Use Class	Specific Use Class (reason)	Situation Type
C. Use of air freight because of superior conditions of carriage	C.1. Reduce risk of having commodities lost, stolen, damaged, or spoiled in transit	C.1. Alternative means of transport have: a. A high incidence of stolen or lost commodities b. A high rate of physical damage c. A high incidence of spoiled or deteriorated commodities
	C.2. Reduce costs and time over which provisions for preserving or protecting goods in transit are required	C.2. Alternative means of transport incur: a. Costly guarding against theft or disappearance b. Heavier or more costly packaging c. Costly environmental control d. Special services or special handling e. Higher insurance costs
	C.3. Enhance control or management of goods in transit	C.3. Expediting through movements by alternative means of transport characteristically requires premium handling and greater difficulty in coordination and documentation
	C.4. Reduce duties in international movements	C.4. Duty is assessed on a gross weight basis, which by definition includes packaging
	C.5. Expedite handling of small lots	C.5. a. Departure or arrival times or the route connections required by alternative forms of transport are not convenient or predictable b. Volume to be moved is sufficient to take advantage of rate breaks offered by air carriers but not sufficient to take advantage of rate breaks offered by other forms of transport

Table IV (Cont'd.)

SOURCE: James Gorham, "Why Companies Use Air Freight - A Consideration In Air Freight Systems Planning and Traffic Forecasting," International Forum for Air Cargo (Montreal: Society of Automotive Engineers, (May 1964)), p. 8

Project takes geographic position into consideration.[59]

A little regarded factor is habit or inertia. "Once a firm's location and distribution decisions are made, its transport alternatives are constrained. The feedback of the transport systems' performance on these decisions tends to be considerable, but only with a time lag. Modeling these feedbacks will be a task far more difficult than that of representing shippers' preferences for alternative modes, given fixed locations. Even this relatively static demand estimation problem has, however, proved formidable. As a consequence, forecasting and quantification of freight demands are among the least understood aspects of transportation planning."[41] R. W. King also endorses habit as a major factor in the shipper's selection of mode.[35]

A final consideration is new product needs. What new possibilities for air cargo will there be in 10 years due to new products being developed? Arriving at a decision concerning the effect of this prevents the air cargo manager from becoming complacent with his present market.

PART 4

USE OF FORECASTS

Probably the best way to evaluate whether a forecast is any good or not is to see who in the industry is using it and for what. If a forecast is not being acted upon it is wasted effort.

The Air Transport Association (ATA) made its own forecast of revenue ton-mile growth rates. It predicted an average growth rate of 11.1% a year through 1973. Using the forecast as a base and adding some financial calculations the ATA presented the airlines' case to the Civil Aeronautics Board (CAB) with regards to rate increases.[3]

The Federal Aviation Agency (FAA) is presently using its own forecasts to plan the national air transportation system. Their forecasts are being inputted into the National Airport Plan (5 years)[26] and the Long-Range Plan (10 years).[25] They have also developed a forecast for use with the Large Air Transportation Hubs' Airport Facility Requirements.[27] A possible reason is that the FAA is the only activity that forecasts operational material (See Table III).

The "United States Air Transportation 1980" study at the University of West Virginia used the FAA large hub forecasts. They proposed an air transportation system

for the U.S. in 1980. Again, they needed operational data and the FAA is the only one who has it.[60]

"Resources in America's Future" use their own forecasts. They make recommendations concerning our natural resources and issue a yearly report.[36]

Reynolds Metals Company used the Lockheed CMRS-59 forecast. They wanted to forecast the need for containers. Using CMRS-59 as a base they extrapolated the number of containers needed to handle the cargo. This gave them a market description for aluminum containers.[61]

The United Aircraft forecast was used to answer a query by Sikorsky. From the original forecast a disaggregation was made. A detailed examination was made of market potential for cargo helicopters. It was recommended that they not be developed due to lack of potential.[17]

There were few examples of forecasts being used for specific reasons. Lockheed, Boeing, and Douglas are using their own forecasts to push their planes. The forecasts of the airlines were either not available or of little use.

PART 5

CONCLUSIONS

A. Lack of data base

If there is one aspect of forecasting for intercity air cargo upon which there is universal agreement, it is the lack of a data base. Practically every source consulted qualifies its results by citing this lack. Those sources that don't do this are either those whose recommendations include a strong emphasis on the need for obtaining such data or those whose purpose was to attempt to fill in gaps in this data.

Westwood Research, Inc. cites the poor quality of data by commodity movement within the U.S.[11] Robert Vos states that lack of past data was a problem encountered at the University of West Virginia. He was interested in city-pair traffic demand.[60] William Jessiman scored the unavailability of good air cargo demand data. He stated that "development of a model which will produce detailed forecasts must await the availability of reliable data which will permit more sophisticated analysis. With prospects of considerable growth in air cargo in the near future, and with the rather sporadic development of that market to date, such a research endeavor is highly recommended."[34] Although Eugene Perle was not specifically concerned with air cargo he also encounted the non-availability of data in such well established industries

as railroads and motor carriers. He made the always valid point that output generated is only as good as input.[44] The Northeast Corridor Project encountered knowledge gaps in its consideration of regional freight transportation. A contributing cause to this problem is the complexity of freight transport. An industry composed of numerous firms operates with a classification system that includes 30,000 items. Also, much of the data gathered is considered proprietary by the firms in the industry.[56]

An employee of one of the major aircraft manufacturers which is engaged heavily in forecasting made an interesting statement. "Perhaps this is a case of the blind leading the blind, because we really do not have complete information in our files to permit even a reasonably accurate assessment of the demand for air cargo on a city-pair basis and by type and nature of commodity."[52] The Transportation Association of America (TAA) in its annual "Transportation Policy Research" cites the lack of data as a major problem of cargo demand forecasting.[54]

Even the international air cargo market, which has probably the best statistics available, is not satisfied. The International Civil Aviation Organization (ICAO) points up a lack of data and information on international air cargo.[33]

Henry McKinnell, Jr. wrote his dissertation because

there was a lack of knowledge about the air cargo market. He disavows his own forecast due to the unsophisticated projections of underlying variables that he had to make.[40] Bruce Allen in both his dissertation[4] and article scores the inadequate data that regulatory bodies are making decisions on.[5]

At a national level, with all the statistics available, there are problems also. Economists complain that there are insufficient on the air freight industry for accurate forecasting.[48] In evaluating transport commodity statistics for use in input/output tables, Jack Faucett commented on requirements of data. "The development of input/output tables requires a great amount of data on production, purchases of materials, and distribution of output for each industry. Most of all, it requires comprehensive coverage, compatibility of classification detail and inter-consistency of the data. Thus, the evaluation of the completeness and accuracy of data systems within the input/output framwork forces a discipline on this undertaking not present in many other uses of data."[55] It is hard to visualize this being met on any disaggregated level such as air cargo. Karen Polenske states the need for an input/output table data base which does not exist. This data base includes regional final demands and interregional shipments. These would be disaggregated to modal shares.[46] Further city-

pair analysis, such as used in CMRS-77, would be a valuable addition to the data base.

There is a real need for a reliable and complete data base. This data must be of both an aggregated and disaggregated nature. Data gathered must be standardized. Standard definitions of what constitutes air cargo and its various elements must be established. There must be ~~condination~~ coordination of international and domestic reporting procedures. It is hoped that the MIT study presently authorized by the Department of Transportation (DOT) will be able to establish criteria for a national data base.

B. Technique vs. Data

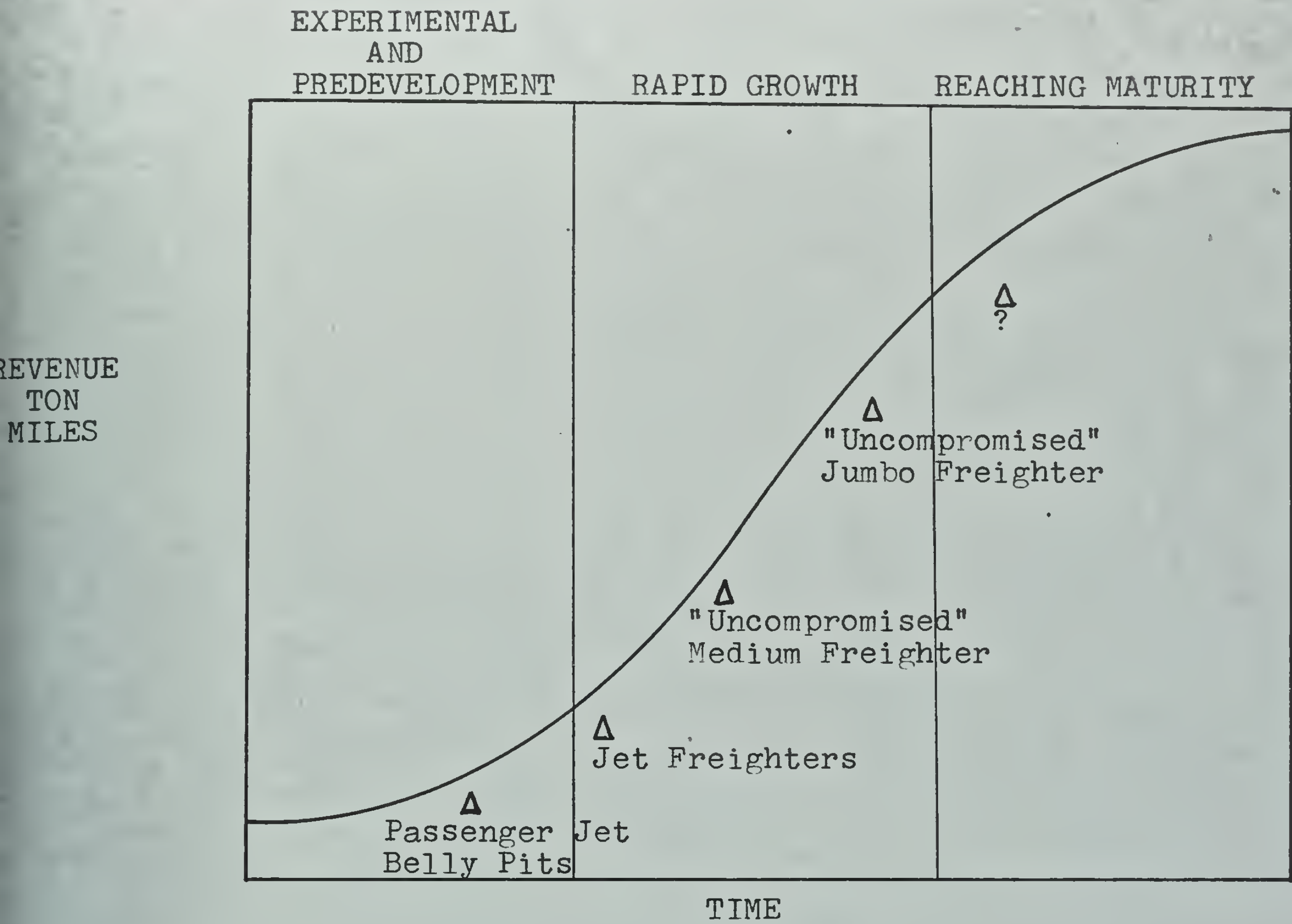
The point raised by Eugene Perle of output only being as good as input[44] raises a question of what techniques are applicable. It does not serve any purpose to be inaccurate to the third decimal place by applying precise techniques to bad data if the forecast need only be rounded to the nearest hundred thousand ton-miles to be useful. While the mechanical extrapolation of trends was classified as naive that was not meant to imply an analytical method is superior in all cases. In Table III we can see that the forecasts of Part 4 that are being used, with the exception of "Resources of the Future" are based on naive methods. Until more accurate data is developed it would appear advisable to use that method which provides the required accuracy with the minimum of sophistication.

Another, argument in this respect is the tendency of forecasts that are accepted to become self-fulfilling prophecies. With the questions previously raised concerning the affect that supply may have had on demand, it would appear that if the supply is less the forecast will be met exactly and if demand is not limited by supply there is a good possibility of the forecast being met.

C. Maturity of air cargo

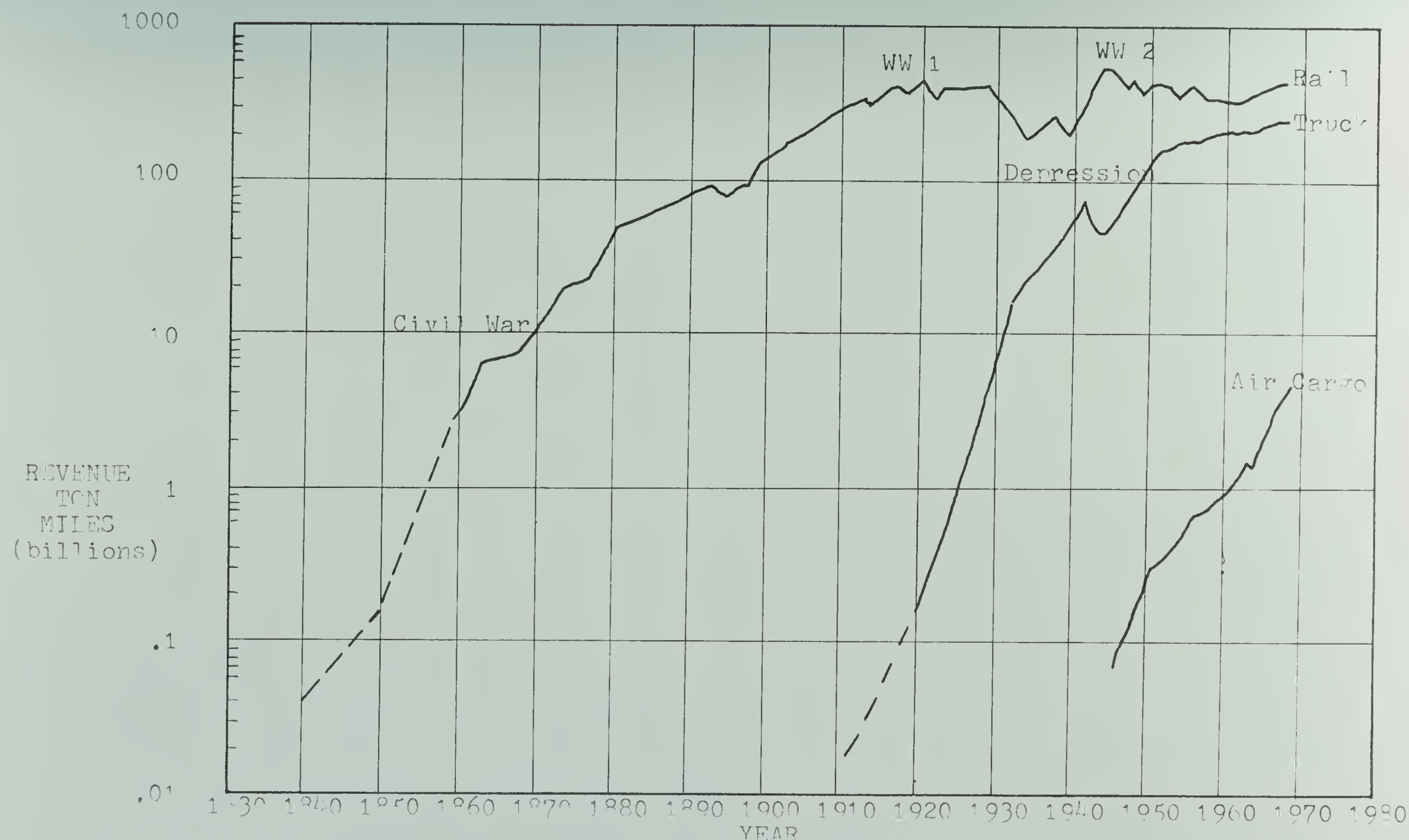
There are two questions of interest in studying air cargo and its forecasting. Where is air cargo in its maturity process? What will be its relationship to passenger revenue? Figure 5.1 represents an idea of what the air cargo life cycle looks like. Figure 5.2 shows the comparison of air cargo to rail and truck historical growth. Full maturity is not expected until after the year 2000.[18]

Air revenue ton-miles are expected to pass revenue passenger-miles by the early 1980's. Reynolds Metals Company expects the cross over in 1976.[61] John H. Shaffer expects cargo lift requirements to exceed passenger lift requirements by 1977 or 1978. He also predicts cargo revenue will exceed passenger revenue by 1982.[51] Douglas Aircraft expects revenue ton-miles to exceed revenue passenger-miles by the early 1980's.[15] The reason this is important is because of the impact this will have on the organization



SOURCE: Douglas Aircraft Company, A Guide to Commercial Air Cargo Development and the McDonnell Douglas Corporation Air Cargo Forecast, report no. C1-801-L0107 (September 1969, revised December 1970), p. 25.

Figure 5.1 Air cargo Development Phases



SOURCE: Douglas Aircraft Company, A Guide to Commercial Air Cargo Development and the McDonnell Douglas Corporation Air Cargo Forecast, report no. C1-801-IC107 (September 1969, revised December 1970, p. 23.

Figure 5.2 Comparison of Historical Growth Between Rail, Truck and Air Modes of U.S. Domestic Cargo Transport

of the air cargo industry. There is a movement toward all cargo airports as a means of handling increased demand. At present a large portion of air cargo travels as belly cargo in passenger airplanes. This does not allow all cargo airports as the belly cargo must go to passenger terminals.[51] Lockheed's forecast of decreasing belly cargo from 1978 on in Figure 2.7 was based on the introduction of the SST. As the SST did not carry cargo, it increased the demand on the all cargo carriers. It will now depend on whether or not the SST is ever introduced as to the correctness of this forecast.

D. Comparison of forecasts

An indication of the difficulty of forecasting demand can be seen when the various forecasts are compared. Three forecasts of total free world air freight are graphed in Figure 5.3. While the forecasts are relatively close for 1970 and 1975, by 1980 they have separated by a wide margin and by 1985 they are greatly divergent. Figure 5.4 shows the same behavior of total U.S. airlines traffic forecasts. The total domestic air cargo forecast diverges even more rapidly. In Figure 5.5 the five forecasts that are compared are close for 1970 but are widely separated by 1975. Even if the Resources forecast is omitted the remaining forecasts still differ significantly. From these comparisons can be seen the uncertainty that exists 10 years or more into the future.

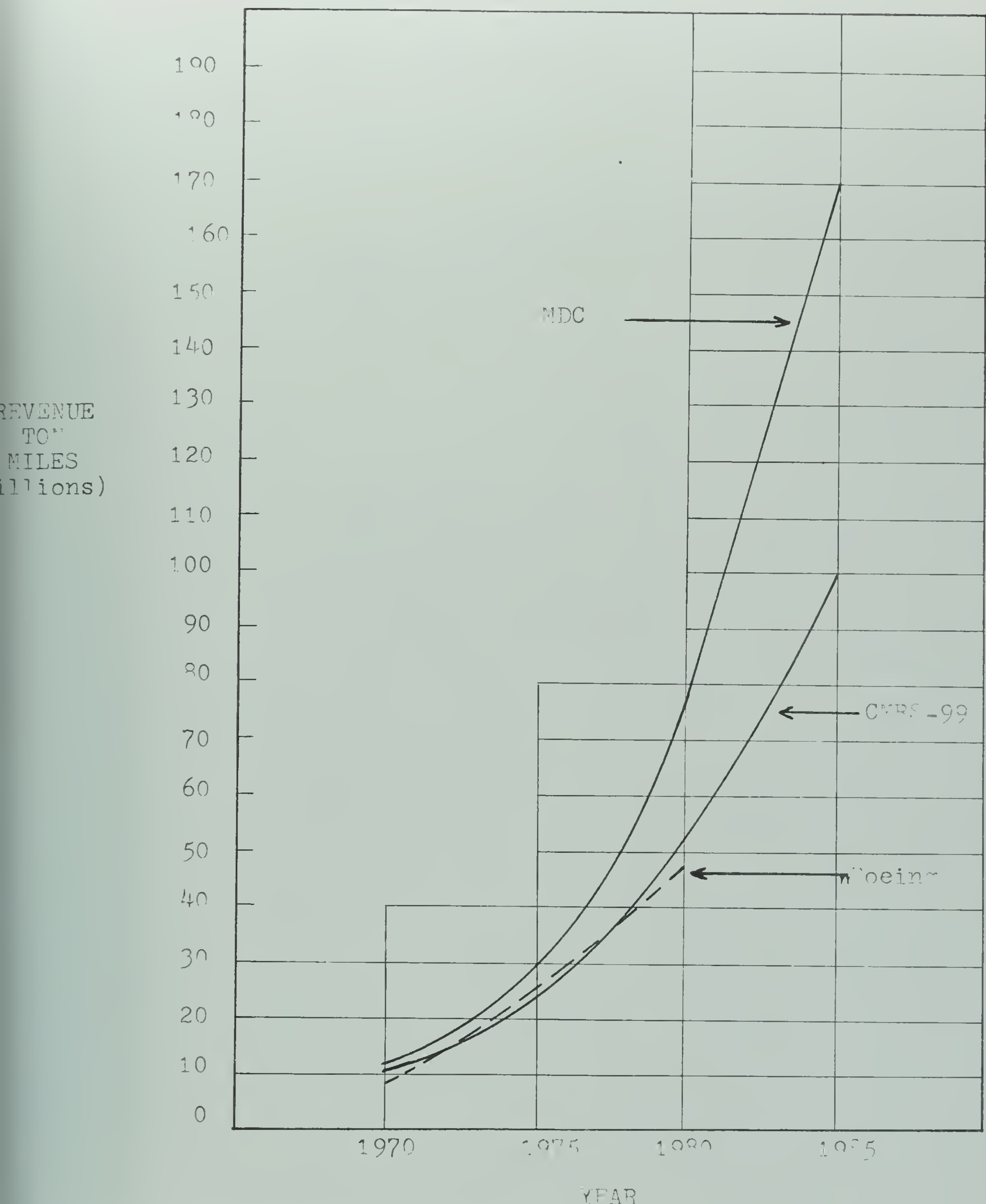


Figure 5.3 Comparison of Total World Freight Forecasts

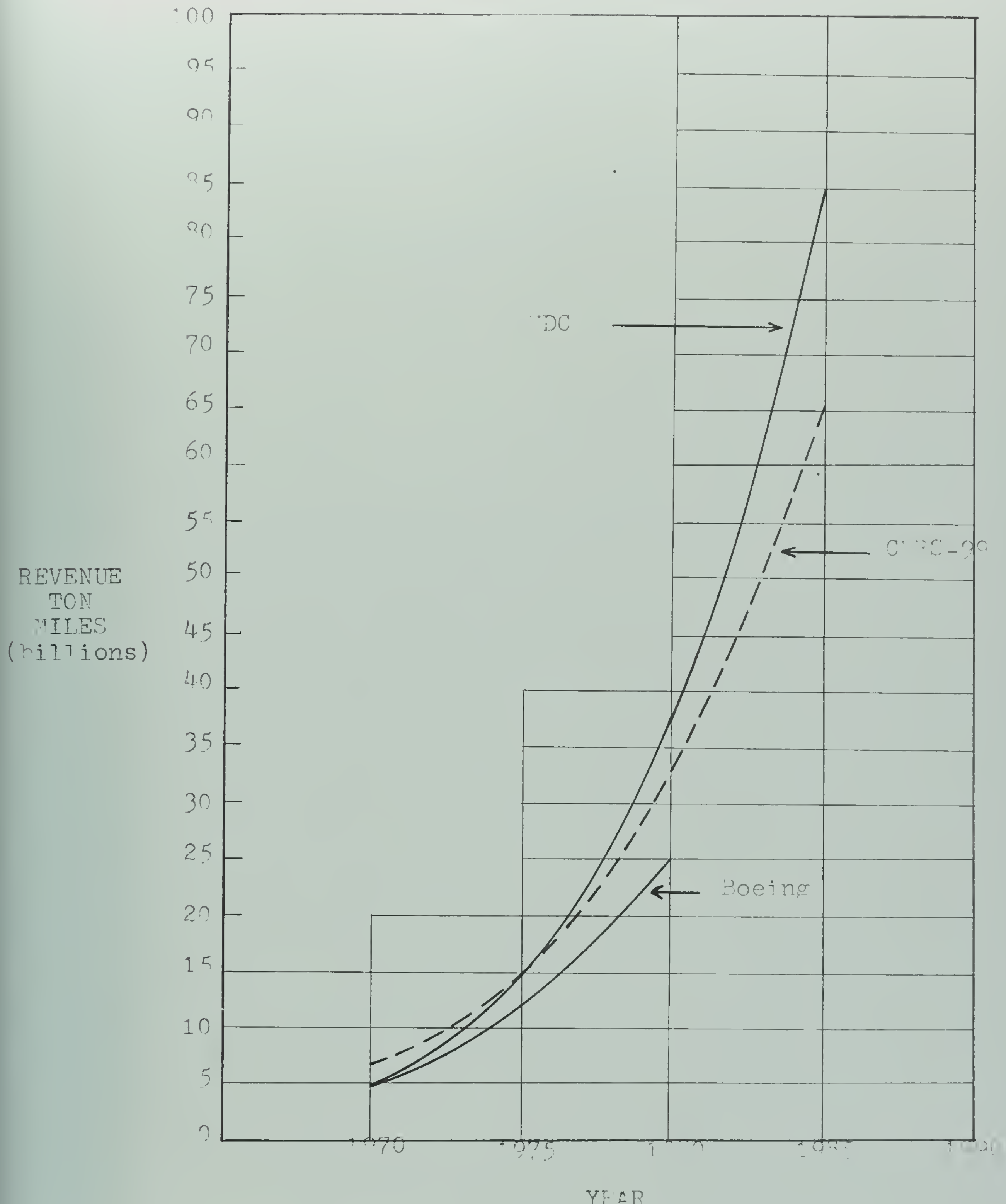


Figure 5.4 Comparison of Total U.S. Airlines Freight Forecasts

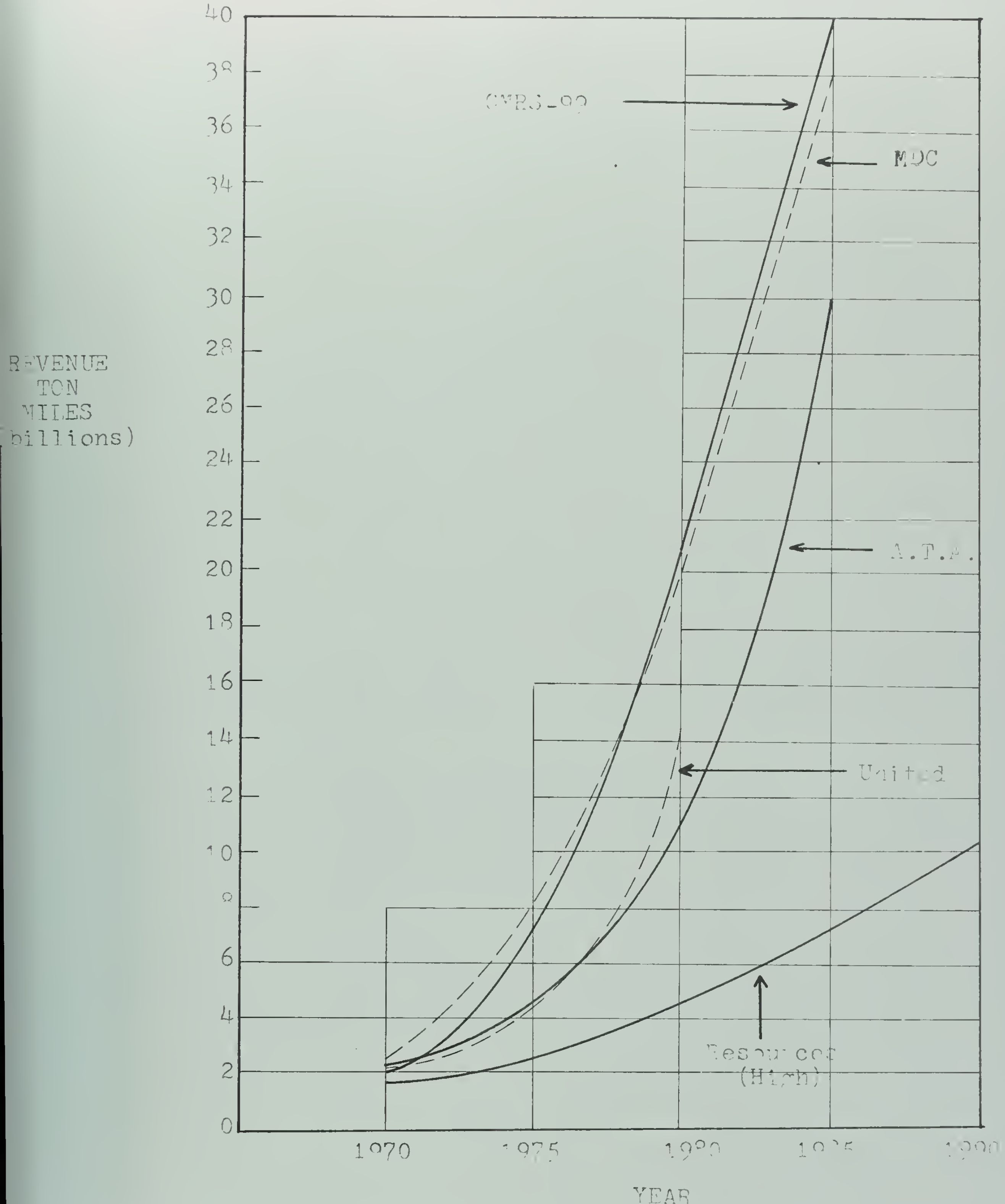


Figure 5.5 Comparison of Total U.S. Domestic Freight Forecasts

With regard to the expected size of the air cargo market even the most conservative forecast predicts a total free world market of 48 billion revenue ton-miles in 1980 compared to 8 billion in 1970. For domestic air cargo the conservative estimate is growth from 2.2 billion revenue ton-miles in 1970 to 10.2 billion in 1980, and 30 billion in 1985.

E. Aggregation vs. Disaggregation

There is a need for both aggregated and disaggregated forecasts. Forecasts are needed at both the executive and planning level. An example of requirements would be the FAA airport capacity criteria for the National Airport Plan, for long-range planning, and for large transportation hubs.

There are several models which disaggregate demand data. These are FORPAC, Macro,[6] the Intercity Transportation Effectiveness Model, and TREND.[57] These models take an aggregate demand forecast, split it among city pairs, and can also develop carrier shares. These models can be used to test the effectiveness of various mixes of facilities. This information is required for effective management, for, as the costs increase, the manager must have available better data with which to make decisions.

Aggregate data is still required also. The coordination of international cargo can be accomplished with more

general data than required for a single route. Also, the further into the future we project the less valid is the argument for a disaggregation need.

F. Emphasis of future research

"Techniques for estimating freight transport demands are, in general, not well advanced. Freight demand models have been relatively crude, single-equation fits to empirical data. Only recently has attention been devoted to study of land uses and the industrial structure as the basis for estimating freight demands, in a fashion analogous to that used in urban transportation studies."[41] While not agreeing completely with the above quote it does reasonably express some of the problems present today.

What is needed to aid in forecasting for intercity air cargo? The Fourth International Forum for Air Cargo reached the following conclusion. "Economics and forecasting play in important role in the design and production of adequate airports and facilities. Maximum emphasis must be placed on a forecasting model based on sound marketing data."[12] Arthur D. Little, Inc. stated that they had attempted to build an econometric model and had failed. They determined that the state of the art and the incomplete knowledge of air cargo precluded their success.[16] It would appear then that we should address ourselves further to the technique on one hand and understanding air cargo demand on the other. H. W. Bruck argues that forecasting

must be better, not for accuracy, but for reasonable parameters.[9]

The Arthur D. Little, Inc. study would indicate that two possibly fruitful areas would be analysis of air penetration by length of haul (Table V) and modal share by shipper group (Table VI). Further study of the relationship of supply and demand as done by Henry McKinnell, Jr. would appear profitable. Any forecasts should be based upon an understanding of the economic theory of the industry. Short-term peak demand also presents a problem.[10] An understanding of seasonal, cyclical and accidental variations is essential if the capacity is to be available to meet them. The question of price-elasticity of demand also needs further examination.[48] While there seems to be a consensus that the demand is elastic for air cargo there is a question raised as to whether this is valid if we consider all-cargo carriers and trunk-line carriers separately. Another possibly profitable area of examination is the relationship of load factors to such things as departures, tons loaded, miles flown, and ton-miles.[14] Any information gained here could temper the Lockheed belly forecast. The total cost of distribution need further emphasis. Customer inertia must be overcome and education as to the advantage of air cargo would increase penetration. James Gorham postulated that the type of industry or commodity is not a determinent of demand.[31] I agree with K. R. Sealy's

TABLE V AIR PENETRATION BY LENGTH OF HAUL

(percent of total ton-miles)

	Shipper Group	All Distance	600-799 Ton-Miles	Over 2000 Ton-Miles[1]
1.	Meat & Dairy Products	-	-	0.1[2]
2.	Canned, Frozen & Other Food Products	-	-	-
3.	Candy, Beverages & Tobacco Products	-	-	-
4.	Textile Mill & Leather Products	.1	.1	.4
5.	Apparel & Related Products	1.5	2.2	2.8
6.	Paper & Allied Products	-	-	-
7.	Chemical, Plastics, Synthetic Rubber & Fibers	-	-	-
8.	Drugs, Paints & Other Chemical Products	.2	-	.3
9.	Petroleum & Coal Products	-	-	-
10.	Rubber & Plastics Products	.3	.2	.9
11.	Lumber & Wood Products, Except Furniture	-	-	-
12.	Furniture & Fixtures	.2	.2	.1
13.	Stone, Clay & Glass Products	-	-	.3[3]

TABLE V AIR PENETRATION BY LENGTH OF HAUL (Cont'd.)

(percent of total ton-miles)

	Shipper Guide	All Distance	600-799 Ton-Miles	Over 2000 Ton-Miles[1]
14.	Primary Iron & Steel Products	-	-	.1[3]
15.	Primary Nonferrous Metal Products	.1	.1	.5
16.	Fabricated Metal Products	.2	.2	.4
17.	Metal Cans & Products	.4	.4	1.0
18.	Industrial Machinery, Except Electrical	.9	1.0	2.1
19.	Machinery, Except Electrical & Industrial	.6	.2	3.4
20.	Communication Products & Parts	4.2	9.5	7.4
21.	Electrical Products & Supplies	.5	.3	1.2
22.	Motor Vehicles & Equipment	.1	.2	.2[3]
23.	Transporation Equipment, Except Motor Vehicles	2.1	.5	8.5
24.	Instruments, Photographic Equipment, Watches & Clocks	2.1	1.5	2.8

1. Except as noted
2. Over 1200 ton-miles
3. Over 1500 ton-miles

SOURCE: Michael D. Dawson, The Outlook for Air Cargo, prepared for Arthur D. Little Inc., March 1968, p. 10.

TABLE VI SHIPMENTS BY MANUFACTURING ESTABLISHMENTS BY

MODE OF TRANSPORT, 1963

(percent distribution of intercity ton-miles)

	Shipper Group	Straight-Line[1] Ton-Miles (billions)	Mode of Transport (%) Rail	Truck For-Hire	Truck Private	Air	Water	Other[2]
1.	Meat & Dairy Products	16.8	46.3	36.2	16.4	-	0.1	1.0
2.	Canned, Frozen & Other Food Products	49.6	74.6	17.1	6.6	-	1.3	.4
3.	Candy, Beverages & Tobacco Products	15.6	46.9	33.1	17.2	-	2.4	.4
4.	Textile Mill & Leather Products	6.5	25.3	58.8	11.5	.1	.1	4.2
5.	Apparel & Related Products	2.2	10.0	62.1	6.7	1.5	.1	19.6
6.	Paper & Allied Products	26.8	70.9	20.7	4.6	-	2.4	1.4
7.	Chemicals, Plastics, Synthetic Rubber & Fibers	36.4	61.8	13.8	3.7	-	20.3	.4
8.	Drugs, Paints & Other Chemical Products	23.6	61.1	24.2	7.9	.2	5.3	1.3

TABLE VI SHIPMENTS BY MANUFACTURING ESTABLISHMENTS BY (Cont'd)

MODE OF TRANSPORT, 1963

(percent distribution of intercity ton-miles)

	Shipper Group	Straight-Line[1] Ton-Miles (billions)	Rail	Mode of Transport (%) Truck For-Hire	Truck Private	Air	Water	Other[2]
9.	Petroleum & Coal Products[2]	276.7	4.3	1.7	1.1	-	91.3	1.6
10.	Rubber & Plastics Products	4.6	37.0	52.4	5.9	.3	.8	3.6
11.	Lumber & Wood Products, Except Furniture	41.5	83.8	6.7	6.9	-	2.5	.1
12.	Furniture & Fixtures	4.9	44.2	34.9	16.7	.2	1.6	2.4
13.	Stone, Clay & Glass Products	33.5	51.2	26.6	15.2	-	6.7	.3
14.	Primary Iron & Steel Products	34.0	61.7	24.3	2.3	-	11.2	.5
15.	Primary Nonferrous Metal Products	11.0	73.2	21.0	3.8	.1	1.3	.6
16.	Fabricated Metal Products	6.1	40.6	36.6	17.7	.2	.4	4.5
17.	Metal Cars & Products	4.6	41.6	46.9	7.0	.4	2.3	1.8
18.	Industrial Machinery, Except Electrical	2.8	25.4	62.2	4.0	.9	.3	7.2

TABLE VI SHIPMENTS BY MANUFACTURING ESTABLISHMENTS BY (Cont'd)

MODE OF TRANSPORT, 1963

(percent distribution of intercity ton-miles)

	Shipper Group	Straight-Line[1] Ton-Miles (billions)	Rail	Mode of Transport (%) Truck For-Hire	Truck Private	Air	Water	Other[2]
19.	Machinery, Except Electrical and Industrial	8.7	51.5	40.0	4.5	.6	.6	2.8
20.	Communication Products & Parts	1.6	29.0	48.6	3.9	4.2	.8	13.6
21.	Electrical Products & Supplies	6.0	48.4	39.5	7.4	.5	.9	3.3
22.	Motor Vehicles & Equipment	15.9	69.8	26.2	2.9	.1	.3	.7
23.	Transportation Equipment, Except Motor Vechiles	1.4	33.0	44.0	16.0	2.1	.8	4.1
24.	Instruments, Photographic Equipment, Watches & Clocks	1.0	28.2	57.8	3.4	2.1	.2	8.3
	Total for all 24 shipper groups	631.8	37.0	14.0	5.0	.06	42.6	1.3
	Total for all shipper groups except No. 9	355.1	62.0	24.0	8.0	.1	4.7	1.2

1. Actual ton-miles are about 24% greater than straight-line ton-miles.
2. Does not include shipments by oil pipeline.

SOURCE: Michael D. Dawson, The Outlook for Air Cargo, prepared for Arthur D. Little,

refutation of this hypothesis.[50] However, the concept of why a customer uses air freight in Table IV is extremely valid and helpful. If quantitative factors could be arrived at for this concept it would be an extremely effective tool.

The other side of the problem is technique. Further development of input/output tables would be very valuable. The combination of these tables with transportation models would provide an effective means of forecasting demand and disaggregating it.[32] Further systems work such as that done at the University of West Virginia[60] could provide effective planning of future transportation systems. Models such as FORPAC, TREND and MACRO should be strengthened. These models provide policy evaluation on a city-pair basis. Overall, the state of the art must wait for reliable data before more precise techniques are valid.

LITERATURE CITED

1. "Air Cargo Growth," Interavia, October 1968, p. 1221.

2. Air Transport Association of American, Executive Summary: A.T.A. Airline Airport Demand Forecasts, A report by the A.T.A., Washington, D.C. (July 1969).

3. Air Transport Association of America, Major U.S. Airlines: Economic Review and Financial Outlook 1969-1973, A report by the Economics and Finance Department of the A.T.A., Washington, D.C. (June 1969).

4. Allen, W. B., "A Model of the Demand for Transportation: The Case of Air Freight." Doctoral Dissertation, Northwestern University, 1969, pp. 73-97.

5. Allen, W. B. and Moses, L.N. "Choice of Mode in U.S. Overseas Trade: A Study of Air Cargo Demand." Transportation Research Forum, 1968, pp 235-248.

6. Baur, Uli, MACRO: Model for Air Cargo Route Optimization, Marietta, Georgia: Lockheed-Georgia Company (1968).

7. Besse, G. and Desmas, G., Forecasting for Air Transport Methods and Results, Institut du Transport Aerien, Paris, France 1966, pp 9-17.

8. "Boeing Traffic Forecast." A pamphlet from the Commercial Airplane Division, Boeing Aircraft, Renton, Washington (1967).

9. Bruck, H. W., "Problems of Planning for the Future." 1966 National Transportation Symposium, New York: American Society of Mechanical Engineers (1966).

10. Casey, Irving J., "Air Freight Transport and the Problem of Peak Demand." A paper presented at the 1968 Joint National Meeting of the Operations Research Society of America. May 1968.

11. Commercial Air Freight Rate Analysis and Forecast, A report by Westwood Research, Inc., Project number WR 155. November 1970, pp 1-5.

12. Conference Proceedings of the Fourth International Forum for Air Cargo, John T. Dyment, Chairman. New York: Society of Automotive Engineers, 1968, p. 77.

13. Cotterman, William Woods, "An Analysis of the Demand for Domestic Air Freight." Doctoral Dissertation, Georgia State College, 1969, pp.90-103.

14. Crawford, J. R., Air Cargo Traffic Characteristics, Marietta, Georgia: Lockheed-Georgia Company (1968).

15. The Current Outlook: Air Transportation Industry - 1970. A report for Douglas Aircraft Company, November 1970.

16. Dawson, Michael D., The Outlook for Air Cargo, Prepared for Arthur D. Little, Inc., March 1968. pp.7-13.

17. Degnan, J. T. and Miller C. E., Study of Large Cargo Helicopters, United Aircraft Research Laboratories report number F-410697-1, Connecticut: United Aircraft Corporation (October 1967).

18. Douglas Aircraft Company, A Guide to Commercial Air Cargo Development and the McDonnell Douglas Corporation Air Cargo Forecast, Report number C1-801-L0107. September 1969. Revised December 1970.

19. Eckard, E. W., Air Cargo Growth Study. Cargo Marketing Research Section report number 49, Marietta, Georgia: Lockheed-Georgia Company (1965).

20. Eckard, E. W., Air Cargo Growth Study. Cargo Marketing Research Section report number 99, Marietta, Georgia: Lockheed-Georgia Company (1967).

21. Eckard, E. W., Free World Air Cargo 1965-1980: Rate Elasticity Forecast, Cargo Marketing Research Section report number 59, Marietta, Georgia: Lockheed-Georgia Company (1966).

22. Eckard, E. W., Free World Belly Cargo Forecast: 1970-1985. Cargo Marketing Research Section report number 169, Marietta, Georgia: Lockheed-Georgia Company (1969).

23. Eckard, E. W., Free World Scheduled All Cargo Capacity, Cargo Marketing Research Section report number 77, Marietta, Georgia: Lockheed-Georgia Company (1967).

24. _The Europe-Asia Market for Air Freight_. A report for the Boeing Company by Stanley H. Brewer, Fremont E. Kast, and James E. Rosenzweig. Renton, Washington, 1963.

25. Federal Aviation Administration, _Air Capacity Criteria Used in Long Range Planning_. Advisory Circular number 150/5060-3A (December 1969). pp. 1-2.

26. Federal Aviation Administration, _Airport Capacity Criteria Used In Preparing the National Airport Plan_. Advisory Circular number 150/5060-1A (July 1968). pp. 1-3.

27. Federal Aviation Administration, _Aviation Demand and Airport Facility Requirement Forecasts for Large Air Transportation Hubs_, Washington, D.C. (August 1967).

28. Federal Aviation Administration, _Aviation Forecasts: Fiscal Years 1967-1977_. Report by the Office of Aviation Economics (February 1967).

29. Federal Aviation Administration, _Aviation Forecasts: Fiscal Years 1971-1982_. Report by the Office of Aviation Economics (January 9171).

30. Fort, Donald M., "Systems Analysis as an Aid in Air Transportation Planning." Paper prepared for the National Transportation Symposium, sponsored by the American Society of Mechanical Engineers, San Francisco, May 1966.

31. Gorham, James, "Why Companies Use Air Freight - A Basic Consideration in Air Freight Systems Planning and Traffic Forecasting." _International Forum for Air Cargo_. Montreal: Society of Automotive Engineers (May 1964). pp. A-1 - A-10.

32. Harman, John E., "Interaction between economic models and models of physical transportation systems" in _Input-Output Analysis and Transportation Planning_. A collection of papers delivered at an economics seminar. Washington, D.C. (1969). pp. 76-84.

33. International Civil Aviation Organization, _Air Freight - Europe-Mediterranean Region_, ICAO Circular number 97-AT/18. Montreal, Canada, 1970. pp. 5-18.

34. Jessiman, William A., "Intercity Transportation Effectiveness Model." A study prepared for presentation to the 37th National Meeting of the Operations Research Society of America. April 1970. pp. 1-48.

35. King, R. W., "The Outlook for the Future in Air Cargo Transportation." Third International Forum for Air Cargo. Chicago: American Institute of Aeronautics and Astronautics (May 1966). pp. 54-59.

36. Landsburg, H. H., Fischman, L. L., and Fisher, J. L. Resources in America's Future. Baltimore: Johns Hopkins Press, 1963.

37. Lockheed Aircraft Corporation, Lockheed-Georgia Company. New Dimensions in Air Commerce, Marietta, Georgia (1969).

38. Lockheed-Georgia Company. The Density Story. A report for the Lockheed-Georgia Company by P. F. Calkins (November 1969).

39. McDonnell-Douglas Corporation, FORPAC: Passenger and Cargo Demand Projection and Forecasting Model. Commercial Operations Research Report number C1-806-739 by Ronald J. Schmidt, W. D. Hamilton, and K. P. Gustafson (June 1969). pp. 1-57.

40. McKinnell, H. A., Jr., "An Econometric Analysis of the U.S. Air Freight Market." Doctoral Dissertation, Stanford University, 1968. pp. 134-149.

41. Meyer, John R. and Straszheim, Mahlon R., Pricing and Project Evaluation. Volume 1 of Techniques of Transport Planning, edited by John R. Meyer. 2 Volumes. Washington, D.C.: The Brookings Institution, 1971. pp. 165-184.

42. Norling, A. H., Future U.S. Transportation Needs, United Research Incorporated, NASA contract number CR-57005. Cambridge, Massachusetts, 1963. pp. VIII-1 - VIII-7.

43. The North Atlantic Market for Air Freight. A report for the Boeing Company by Stanley H. Brewer, Fremont E. Kast, and James E. Rosenzweig. Renton, Washington, 1962.

44. Perle, Eugene D., The Demand for Transportation: Regional and Commodity Studies in the United States. Department of Geography Research Paper number 95, University of Chicago, 1964. pp. 119-126.

45. Perreault, W. D., "Air Cargo - Where the Horizons Are Unlimited." Speech at the International Conference of Air Cargo in the Next Decade. London, England, February 1970. pp. 19-20.

46. Polenske, Karen R., The Study of Transportation Requirements Using National and Multiregional Input-Output Techniques. Prepared for U.S. Department of Transportation (April 1967).

47. Reeher, David H., The Domestic Air Freight Industry and Introduction of Large Subsonic Transports. Analytic Services, Inc., Falls Church, Virginia. August 1967. p. 16.

48. Sandiford, P. J., "Discussion". International Forum for Air Cargo. A discussion of "Why Companies Use Air Freight - A Basic Consideration in Air Freight System Planning and Traffic Forecasting" by James Gorham (May 1964). pp. A14-A16.

49. Schreiver, B. A. and Seifert, W. W., Air Transportation 1975 and Beyond - A Systems Approach. Cambridge: MIT Press, 1968. pp. 150-151.

50. Sealy, K. R. and Stratford, A. H., "Discussion" International Forum for Air Cargo. A discussion of "Why Companies Use Air Freight - A Basic Consideration in Air Freight Systems Planning and Traffic Forecasting" by James Gorham (May 1964). pp. A11-A13.

51. Shaffer, John H., "Is the All-Cargo Airport On the Way?" Airport World and Aviation Systems Management, (January 1971).

52. Stoessel, R. F., "Our Status Today." International Forum for Air Cargo. San Francisco: Society of Automotive Engineers (June 1969). pp. 1-5.

53. Study of Air Cargo and Air Passenger Terminal Facilitation, by Simat, Helliesen, and Eichner, Inc., Washington, D.C. March 1969.

54. Transportation Association of America, Transportation Policy Research, 6th edition, prepared by the Research Department of the TAA, Washington, D.C., 1969. pp. 11-12.

55. U.S. Department of Commerce, Evaluation of Transportation Commodity Statistics for Use in Input-Output Tables, a paper prepared for the Department by J. G. Faucett, E. J. Kirschner, and A. T. Wood. Silver Spring, Maryland: Faucett (Jack) Associates, 1967. pp. 1-5.

56. U.S. Department of Transportation, Freight and Commodity Networks. Department of Transportation contract number 8-35049 (July 1968). pp. 1-4.

57. U.S. Department of Transportation, Study of the Feasibility of the Lockheed Transport Model As Applied to the U.S. Intercity Transport System. Prepared by Lockheed Aircraft Corporation. Los Angeles, 1968. pp. 1-1 - 1-5.

58 U.S. Department of Transportation, Transportation Demand Projections and Forecasts. A report by Richard Lawson. 1968.

59. Vinod, H. D., "Econometric Estimation and Forecasting of Freight Demand" in Studies on the Demand for Freight Transportation, Vol. 1. Princeton: Mathematica, 1967. pp. 31-45.

60. Vos, Robert, United States Air Transportation 1980, Summer predoctoral fellowship program, NASA Langley Research Center, West Virginia University, 1969. pp. 2-42 - 2-44.

61. Wood, Frank E., Air Cargo Container Study. Prepared by the Market Research Department of Reynolds Metals Company (October 1968). pp. 17-18.

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city air cargo demand.